JANUARY 1957

Product Engineering

THE McGRAW-HILL MAGAZINE OF DESIGN ENGINEERING
FIVE DOLLARS A YEAR

Temperature Rise in
Induction Motors

Glass-Metal Seals

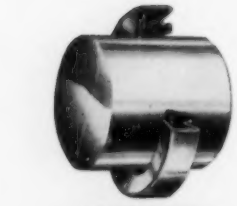
Photo Reproduction Systems

Pressure Control Valves

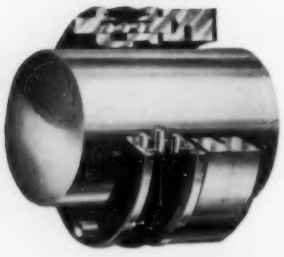
Magnetostriction in design—page 162

cooperative research

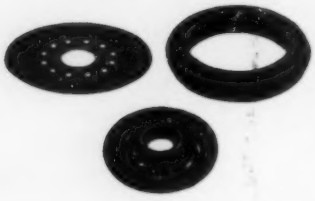
covers this wide range of products



SHAFT-TYPE OIL SEALS More than 20 types, forming over 7,500 size combinations for shafts from ¼" to 50" O.D., are available — thousands from stock. These seals are used for the vast majority of shaft sealing problems from simplest dust exclusion to high-speed, high-temperature fluid retention and foreign matter exclusion under extremely rugged operation where high sealing efficiency must be maintained over long service life.



END FACE SEALS For critical sealing problems outside the capabilities of shaft-type seals, there are C/R End Face Seals, which operate on the principle that two smooth, flat surfaces, one rotating on the other at right angles to the shaft, form a leakproof seal. They require minimum pressure to maintain face contact, create minimum friction, heat and power loss, and give unsurpassed performance under the most severe conditions.
Typical applications of C/R End Face Seals include: sealing track rollers of crawler tractors; sealing high-speed accessory drives in aircraft; sealing medium speed applications such as gear cases of washing machines, dishwashers and similar home appliances.



SIRVENE SYNTHETIC RUBBER PRODUCTS The advanced level of compounding and molding elastomers and special materials to critical tolerances achieved by C/R Sirvene Engineers is a widely established fact. They will design, compound and produce a part to your exact specifications of hardness, elasticity, and resistance to aging, temperature, oils, solvents or chemicals — with dimensional uniformity and consistent high quality, regardless of quantity. Holding to extremely close tolerances is standard procedure. A typical list of products includes oil seal packings, diaphragms, cups, boots, gaskets, plugs, impellers, valve inserts and way wipers — to name but a few. The experience and facilities available to you from C/R's Sirvene Division are unrivaled in the industry.

SIRVIS-CONPOR MECHANICAL LEATHER PRODUCTS The typical range of mechanical leather products includes oil seal packings, cups, boots, washers, gaskets, couplings and valve discs, but encompasses any part wherein high tensile strength, flexibility, high resistance to pressure, wear, shock, and vibration are desired. Cups of C/R's Conpor impregnated Sirvis leather products are operating at pressures up to 10,000 p.s.i. They are insoluble in most hydraulic oils and compatible with a wide range of other oils, solvents and gases. C/R boots of Sirvis leather, canvas, nylon or elastomer impregnated fabric can be produced in sizes two stories high or not bigger than your thumb for use in the protection of eccentric, universal or reciprocating action. Whatever your sealing or protection problem, bring it to Chicago Rawhide. C/R Engineers are constantly developing new mechanical leather designs for special and universal application.

Please write direct or contact your nearest C/R sales engineer about your problem in fluid sealing or related fields.

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Offices in 55 principal cities. See your telephone book.

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Export Sales: Geon nternational Corp., Great Neck, New York

C/R Products: C/R Shaft and End Face Seals • Sirvene (synthetic rubber) molded parts • Sirvis-Conpor mechanical leather cups, packings, boots • C/R Non-metallic Gears • C/R Rawhide and nylon hammers.

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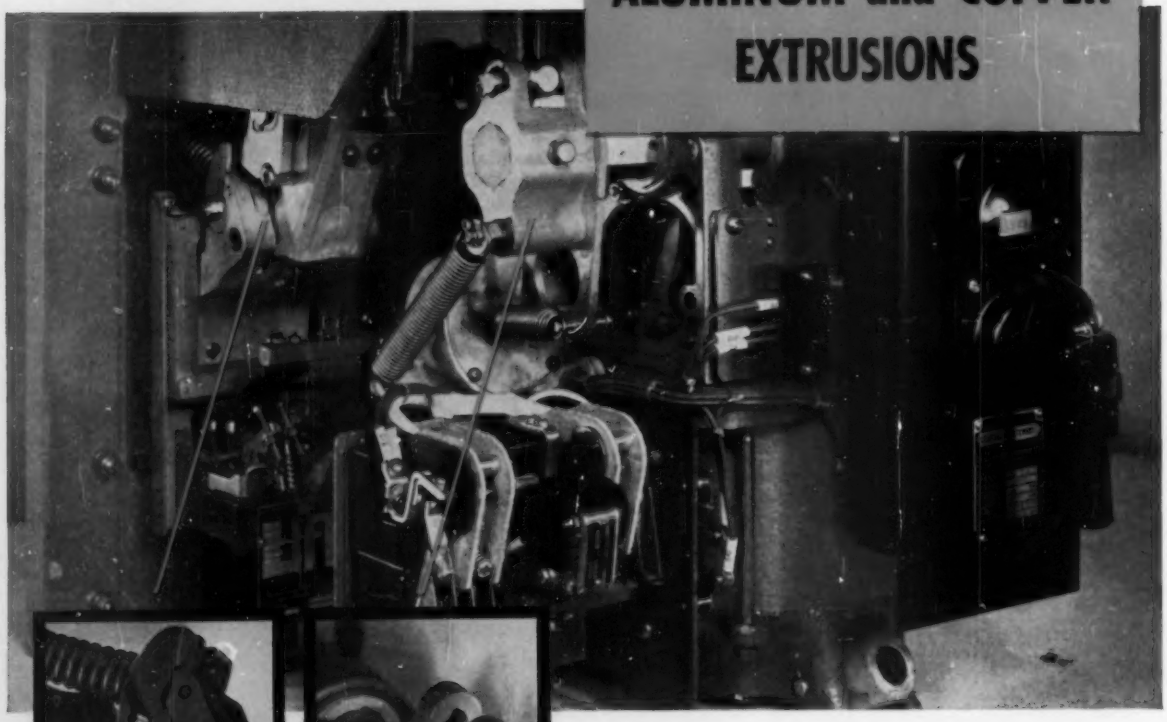
I-T-E CIRCUIT BREAKER—KD (3,000 amp. rating) showing progressive assembly with Revere Copper and Aluminum Extrusions in place. I-T-E Circuit Breaker—KE is same type with 4,000 amp. rating.

REVERE
ALUMINUM and COPPER EXTRUSIONS



COPPER
for conductivity

ALUMINUM
for economy

—form a Money-Saving team in latest

I-T-E CIRCUIT BREAKERS

Revere T. A. Service an Important Factor in Ultimate Design of Parts

The larger of the two extruded and drawn copper shapes shown at extreme left started out on the drawing board as two pieces. It was thought that a single shape of this size could not be made satisfactorily. At this point, I-T-E Engineers got together with Revere's T. A. (Technical Advisory) Service and threshed things over. The final result is the one-piece extrusion shown and a reduction in machining time.

Aluminum was selected for the other extrusion shown because I-T-E found that it cost less per pound of metal and had a higher strength ratio when compared to a casting. Also, space was a factor. In all, Revere supplies 5 copper and 2 aluminum extrusions for KD and KE type I-T-E Circuit Breakers. All were designed to fit specific requirements of I-T-E Engineers. Where it could be used satisfactorily, aluminum was applied because of economy, while current carrying members called for copper.

This is still another example of Revere supplying the metal that will do the best job and with the greatest economy . . . be it aluminum, copper or any one of their alloys. So, with new things happening all the time in non-ferrous metals it can pay you to keep in close touch with Revere.

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Product Engineering

JANUARY 1957 Vol. 28 No. 1 The McGraw-Hill Magazine of Design Engineering

Choosing Equipment for Drawing Reproduction ..... Arthur W. Tabe: 135
Comparison of printing and photocopying machines as related to needs of medium-sized engineering department.

Fluidized Plastic Coatings for Corrosion Resistance ..... J. A. Neumann, F. J. Bockhoff 140
Powder dip process for intricate parts; mechanism of fluidization, coatings available.

Design Features in New Products 144
Stepped piston in air compressor; carburetor operates in any position; friction transports dictation tape; shot-peened gears in transmission; higher, safer tractor shovel; micrometer counts light fringes; orbital motion mechanism in saw; cam drives indexing table; hydrostatic bearing for thrust, radial loads; coupling-rod assembly.

Grooves for Retaining Ring Assemblies ..... Hugo Wurzel 158
Function of groove, relation to retained part; how to cut grooves properly, effects of improper grooving.

Magnetostriction: A New Design Tool ..... Edmund M. Wise 162
Materials, performance characteristics, design factors, applications for method of generating large static forces or small displacements.

Controlling Temperature Rise in Induction Motor Drives ..... Charles C. Libby 167
Significance of temperature rise; effect of duty cycle, braking methods, base speed and load inertia on motor temperature; improving ventilation and cooling in restricted spaces; factors limiting overload; speed sensitive loads and mechanical limitations.

Clock-Escapement Mechanisms ..... T. K. Steele 179
Analysis of balance-wheel and run-away clock escapements; formulas, curves and typical applications, including timers, regulators, accelerometers, velocity indicators.

Design Hints for Laminated Plastics ..... George A. Ebelyare 186
Some of the special considerations involved in using materials combining thermosetting resins with laminar fillers.

Glass-to-Metal Seals ..... Thomas H. Mariner 188
Five types of seals, factors involved in selection; alternates to gasketed assemblies.

Limitations on Cam Pressure Angles ..... Harold A. Rothbart 192
Selection of maximum angle based on forces acting on cam followers.

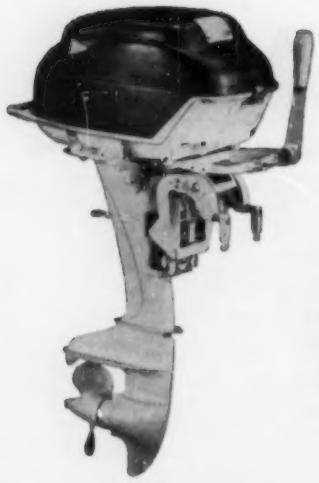
Hydraulic Control Valves—Part II ..... John J. Pippenger 196
Construction details, operational idiosyncrasies, drainage, circuit applications of pressure control valves of counterbalance, sequence, unloading, pressure reducing types.

A New Oil-Less Bearing Material ..... John D. Shaw and Walter V. Knopp 203
Characteristics, advantages and limitations of full density graphite-metal powder combinations, self-lubricating at extreme temperatures and pressures.

Reducing Trial and Error in Compression Spring Design ..... J. J. Intintolo 206
Graphical method for obtaining boundary of acceptable spring dimensions, based on variables of spring design.

Stress Cycles in Planetary Gears ..... Lloyd E. Iversen 219
Tabulation of four types of gear trains, with formulas for stress cycles and speed and torque ratios for certain conditions.

INTERESTING TO NOTE 5
DEVELOPMENTS TO WATCH 9
DESIGN PERSPECTIVES 129
EDITORIAL 133
TECHNICAL NEWS 209
COMING EVENTS 217
NEW COMPONENTS AND MATERIALS 224
CATALOGS AND BULLETINS 332
SANS, SOUCI 351
ENGINEERING ABSTRACTS 357
NEW BOOKS 362
READERS' LETTERS 381
PRESS PREVIEWS 387



How Armco 17-4 PH Stainless Steel Gives these Motor Shafts Longer Life

Outboard motor manufacturer uses 17-4 PH Stainless because of its combination of high strength and corrosion resistance.

Before development of Armco 17-4 PH Stainless Steel, best material for these vital outboard motor parts was one of the standard hardenable stainless grades.

Now, made of 17-4 PH, the shafts not only have a higher yield strength but better corrosion resistance as well. According to company officials, Armco 17-4 PH provides a finished product that lasts longer, especially in salt water service. In addition, their shop men like the excellent heat treating characteristics of the material.

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Armco 17-4 PH Stainless Steel offers you a corrosion resistant steel that can be hardened to a typical tensile strength of 200,000 psi by a simple, low temperature heat treatment. It resists corrosion better than standard hardenable stainless grades. Hardening is done at only 900 F for 1 hour, produces no distortion or scale. Machining and fabricating properties are good.

Armco 17-4 PH Stainless Steel is available in a wide range of sizes of bars, wire and billets. Armco 17-7 PH, a companion grade with similar properties, is produced in sheets, plates, and strip as well as bar and wire.

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17-4 PH Stainless Steel

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Sheffield Steel Division, Armco Drainage & Metal Products, Inc., The Armco International Corporation

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THIS MONTH'S COVER

Reproduction of an original Terrence Cuneo painting showing the testing of a magnetic alloy at an International Nickel laboratory. The instrument is a Sucksmith magnetic balance for measuring forces developed in a magnetic field through the use of a torsion balance. For a thorough-going discussion of magnetostriction as a design tool, see page 162.

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Product Engineering
A McGRAW-HILL PUBLICATION

JANUARY, 1957 Vol. 28, No. 1

Published monthly, with an additional issue in Mid-October, by the McGraw-Hill Publishing Co., Inc., Executive Editorial, Advertising and Subscription offices McGraw-Hill Building, 330 West 42nd Street, New York 36, N. Y. Publication office, 99-129 North Broadway, Albany 1, N. Y. Donald C. McGraw, President; Paul Montgomery, Executive Vice President; Joseph A. Gerardi, Executive Vice President and Treasurer; Hugh J. Kelly, Executive Vice President; John J. Cooke, Secretary; Nelson Bond, Executive Vice President, Publications Division; Ralph B. Smith, Vice President, Editorial Director; Joseph H. Allen, Vice President and Director of Advertising Sales; J. E. Blackburn, Jr., Vice President and Circulation Director.

FOR SUBSCRIPTIONS, write to: Subscription Service, 330 West 42nd Street, New York 36, N. Y. Subscriptions are solicited only from executives, engineers and consultants engaged in the design of machinery and other engineered products. **Orders must indicate company and position.** Allow one month for change in address.

Single copies 50¢. United States and possessions, $5 for one year, $8 for two years, $10 for three years; Canada, $6 for one year, $9 for two years, $12 for three years; other Western Hemisphere and the Philippines, $15 for one year, $25 for two years, $30 for three years; all other countries, $25 for one year, $40 for two years, $50 for three years. Second class mail provisions authorized at Albany, N. Y. U. S. A.
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Interesting to Note . . .

How the Thermometer Got Its Degree

UNTIL a few centuries ago the question "how hot is hot" was as ambiguous as "how high is up." Lord Kelvin, creator of the Kelvin scale of temperatures once said, "We know nothing about a thing until we can measure it and express it in numbers." The problem of bringing the semantic description of a temperature to a numerically expressed measurement dates back to Fahrenheit, when in 1714 he presented us with the still-used mercury thermometer and its scale. However, several years before Fahrenheit announced his thermometer, Sir Isaac Newton worked with the problem of thermometry using a tube filled with linseed oil. The starting point of his scale was the temperature of the human body; Newton called this point 12. Fahrenheit experimented with Newton's scale but found it too restricting, so he arbitrarily multiplied Newton's point of 12 by 8, thereby designating the temperature of the human body as 96. Fahrenheit then placed his thermometer in a mixture of snow, ice, and salt and labeled the resulting reading zero. The scale thus established gave a reading at the 32nd mark as the melting point of ice and the 212 mark as the boiling point of water. It was Anders Celsius, a Swedish astronomer, who first proposed making the interval between the formation of ice and steam 100 divisions. Hence, the Centigrade scale.

Today we have thermometers which can record the body temperature of an ant, the surface temperature of the sun, or the temperature of a candle flame more than a mile away. Exacting too, is the control of temperature rise of electric motors, the subject of an article appearing on page 167.

Whistling in the Dark

ON a Paris street corner in the year 1839, a man paused to have his shoes brushed. Unbeknownst to him, a box-shaped object was being pointed at him from the attic studio of Louis Jacques Mande Daguerre. Many minutes later, that stranger became the first man in history to have been photographed. From those pioneer days great strides have been taken in the science of photography. One of the most interesting involved not a scientist, but two musicians.

Leopold Godowsky, son of the great Viennese pianist, and a polished violinist in his own right, together with Leopold Mannes, also the son of a distinguished musician and himself a student of the piano, mutually shared the same interests: music and photography.

In 1922, the two young men were proportioning their time between music and their interest in color photography. They first tried to produce color pictures by using a camera with three lenses and three filters, one for each of the three primary colors and forming a single image upon a photographic plate. Although working in the right direction their method wasn't

(Continued on page 7)

This angular gear arrangement drives both a blower and a pump on a twin rotor helicopter. Gleason engineers made design and production recommendations and produced prototypes for the manufacturer.
Combination: 18 x 34 x 41; D.P. :7.56; Face ½"; Tooth Spacing—within .0003".

You can solve your angular power transmission problems, too!

The designers of this gear unit achieve greater flexibility within a limited amount of space by placing the drive shafts at an angle and using one source of power to drive two auxiliary units.

Perhaps a similar gear drive would make your product designs more flexible. Such bevel gear drives permit a more compact design requiring less weight and the ability to carry higher loads.

Our engineers are ready to help you work out applications for bevel and hypoid gears—just as they helped the helicopter manufacturer with the design illustrated above.

We recommended the proper gear sizes and reviewed the mountings and lubrication for the drive. Then we produced and tested prototypes of the unit.

If you would like to discuss an application with one of our representatives, please write. You will also find these Gleason Technical Handbooks helpful: 20° Straight Bevel Gear System; Spiral Bevel Gear System; ZEROL Bevel System.

GLEASON WORKS

Builders of bevel gear machinery for over 90 years

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satisfactory. The team was eventually invited to join the research department at the Eastman Kodak Co.

They accepted eagerly and in 1931 went to Rochester and again divided their time between color research and their love for music. Though they found harmony in their music, life in the laboratory was hard. Their associates referred to them as "those musicians" when they timed their darkroom experiments with great accuracy by whistling Brahms' C-Minor Symphony at the speed of two beats to the second. After continued work, they achieved a three-color process, in which three layers of emulsion are used to blend the primary color in proper proportions. In 1935, the process was given to the public and called—Kodachrome.

A review of present day methods for reproducing drawings begins on page 135.

Big Ben

THE pride of England and a masterpiece of horological engineering, "Big Ben" rests in the Palace of Westminster some 320 ft above the streets of London. The giant clock was conceived by Charles Barry in 1835 as a part of the new Houses of Parliament replacing the buildings destroyed by fire the previous year. The clock was originally designed and partially constructed by Benjamin L. Vulliamy. However, when a rival clockmaker, E. J. Dent, appealed to Parliament to allow him to complete the construction of the "dream clock," the matter was discussed so heatedly that Parliament demanded an open competition. After a long bitter controversy, it was decided that Edmund Denison and E. J. Dent be allowed to finish the great clock. Denison designed the now famous "double three legged gravity escapement" which is still incorporated in turret clocks of today. The clock, complete with four quarter chime bells and a 13-ton hour bell, went into operation in 1859.

Naming of the clock was the next problem confronting Parliament. After days of debate, Sir Benjamin Hall, a man of immense physique, and affectionately called "Big Ben," delivered a long oratory proposing the name of St. Stephen. When he concluded, a perturbed member of the house shouted, "Why not call it BIG BEN and have done with it?" The House was overcome with laughter and Big Ben it became.

Further material on escapements for today's clock mechanisms may be found on page 179.

Bottles by the Billions

ONE of the commonest household accouterments is the glass bottle. Today, America's glass container manufacturers produce 19-billion of them yearly in all sizes, shapes and varieties. It wasn't too many centuries ago, however, that the glass container was a priceless possession. In Egypt four thousand years back, only a bottle made of glass was suitable for a queen's rare cosmetics; at elaborate funeral ceremonies, tiny glass phials were used to catch the tears of mourners.

According to the Roman historian, Pliny, glass was invented by Phoenician sailors when their beach fires accidentally heated up the sand. Early bottle making was a most tedious task. The craftsman would dip a long metal rod into a cauldron of molten glass, extract a thin strand and wind the threads of glass around a mold of sand. Around 100 B.C., an Egyptian tried blowing into a hollow tube and produced the first glass bubble. From that point, the bottle became an important item of commerce. The 17th century glassblowers of Murano, Italy, were famous for their skill and design. A bottle that failed to meet their high standards was called a "fiasco" and discarded. (Today, the word "fiasco" means "bottle" or "flask" in Italian and "failure" in English.)

Glass has found many industrial applications, but the sealing of glass to metal, is still a problem today. An article dealing primarily with hermetic glass to metal seals appears on page 188.

Before the Lindy Hop

ON May 21, 1927, Charles A. Lindbergh achieved international glory for his solo flight across the Atlantic. Yet not many days before, his name was virtually meaningless. When he piloted "The Spirit of St. Louis" to Curtiss Field, Long Island, from St. Louis, he was over the airfield at the same time Cdm. (now Rear Admiral) Richard E. Byrd was scheduled to land at adjoining Roosevelt Field. A third plane, that of the Pioneer Instrument Co., containing company president Charles Colvin and a photographer from the New York Daily News, was also airborne at this time. The News photographer wanted to obtain aerial pictures of Byrd before he landed. After taking his pictures, the photographer's attention was called to Lindbergh's plane in the distance. Mr. Colvin suggested that some pictures also be taken of "The Spirit of St. Louis" before it attempted its famous flight to Paris. The photographer however, believed that Lindbergh was nothing more than a friend of Colvin's and refused to take any "personal pictures."

Charles Colvin, now director of the Colvin Laboratory, East Orange, N. J., was responsible for outfitting Lindbergh's plane with its complete instrument panel. For the first time an earth inductor compass which relies on the earth's magnetic field was tried and proven successful in transoceanic aerial navigation.

Other navigational instruments using magnetic principles have been highly developed. Sonar, for example, uses the principle of magnetostriction. An article discussing magnetrostriction as an industrial design tool appears on page 162.

More Weight in Less Space with Mallory 1000 Metal

WHATEVER the nature of your assembly—gyroscope rotors, counterbalances, balancing weights, or similar mass components—you can get more weight into less space with Mallory 1000 Metal.

Mallory 1000 has a density of 16.96 gm/cc—twice that of brass or steel, and is far stronger than lead! It features ready machineability—even to a high surface finish.

More weight in less space means real savings in several ways. For example, housings can be made smaller—thus overall assemblies become smaller for a savings in cost and weight. Mallory 1000 Metal provides exceptionally high inertia in a smaller space, increasing the sensitivity of gyroscopic or balancing action, yet reducing the overall unit size.

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Developments

To Watch

A CAST CORROSION RESISTANT ALLOY WITH BETTER MECHANICAL PROPERTIES. . . .

. . . than the 18-8 stainless, is reported to have a tensile strength that is twice as great and a yield strength which is three times that of the 18 Cr-8 Ni stainless steel. Composition of the new stainless is 25 per cent Chromium, 5 per cent Nickel, 3 per cent Copper, 2 per cent Molybdenum, and a low carbon content, with 0.04 per cent considered a maximum. Originally developed to equal the corrosion resistance of the 18-8 stainless, the new alloy is more corrosion resistant, and twice as hard in the non-hardened condition as 18-8. The alloy can be aged by heating in a temperature range of about 700-900 F. Tests at room temperature showed a Brinell Hardness of 321; a yield strength of 120,000 psi; a tensile strength of 140,000 psi; and an elongation of 16 per cent. Called CD-4 MCu by the Alloy Casting Institute, the new stainless is for medium and slightly elevated temperatures (about that of 18-8), and at present should not be considered for high temperature applications. For handling such acids as nitric acid, it is as good as 18-8. Its seizing and galling characteristics are good, and its machinability either annealed or hardened is better than 18-8. Developed at the Ohio State University Research Foundation, the new alloy has yet to be tested for its weldability, workability.

ALUMINUM HAND FORGINGS WITH LOW INTERNAL STRESSES. . . .

. . . are possible with a new tempering process announced by The Aluminum Company of America, 1501 Alcoa Bldg., Pittsburgh 19, Pa. Advantages are reported to be reduced machining and straightening time, with a consequent reduction of production costs. Called the T65 temper, the new treatment has been applied to hand forging and rolled rings in alloy X7079. Internal stresses are said to be substantially reduced and warpage from machining lessened in contrast to the T65 temper, although the mechanical properties of the two are the same. A machined hand forging in alloy X7079-T65 shows about the same warpage found in stretched plate and extrusions. The new process is based on precision controlled cold reduction, following solution heat treatment. Alcoa is offering these hand forgings and rolled rings in sizes up to 6 in. thick and 72 sq in. cross section. The company hopes to extend the T65 temper to other alloys, and is presently trying the new treatment to stress relieve die forgings.

BALANCE MECHANISM LIKE THAT IN THE HUMAN INNER EAR . . . .

. . . will be used to detect the slightest variation in the position or speed of a missile or manned aircraft. Developed by Northrop Aircraft, Inc., 1001 E. Broadway, Hawthorne, Calif., the instrument weighs slightly more than one ounce, is made of glass tubing, and even resembles the convolutions of the inner ear in shape. Twin tubes of glass are joined together at the bottom by two smaller glass tubes. Inside, an electrolytic solution covers tungsten electrodes which are fused into the glass material. The electrodes are connected to a Wheatstone bridge circuit. Signal voltages caused by deviation in course are transmitted to the guidance system which starts corrective controls. Housed in a temperature controlled capsule to maintain constant values, the device is used primarily in missiles and aircraft, and can be used as a vertical-sensing mechanism in military weapons, automatic precision leveling in survey operations, and has potentials for seismographs.

(*Continued on page* 10)

Developments to Watch

SHEET STEEL IS BEING CAST . . . .

. . . by a method which eliminates all of the steps between the converter and the sheet rolling mill. Just announced by Russia, the process is a combination of continuous casting and rolling. It starts with the pouring of the molten steel into a graphite funnel that spreads the steel over the required width. The molten steel reaches two water-cooled rollers, the lower one being greater in diameter and mounted below the funnel. The smaller diameter upper roller is mounted farther away from the mouth of the funnel to permit a better spread of the material on the lower roller. The difference in temperature between the hot steel and the cooled rollers brings about a crystallization of the steel first on the under side by the lower roller then on the upper side by the second roller. The coarse-grained material is cut into piles of sheets, which are given a heat treatment before the trimming and surface treatment stages. The heat treatment, where the primary cementite is changed to graphite, is accomplished at 1850 F, and requires about three to four hours for a stack of 500 sheets. The second part of this process is the slow cooling off to 1200 F. Compared to the cast sheets, warm rolling of the steel sheets requires machinery 9 times that needed for cast sheets; electric energy needed is 12 times more; primary fuel needed is 8 times greater; and metal consumption is 25 per cent higher.

This cast sheet material is reported to have good plasticity, and with 7.1 grams per cu centimeter, has less weight than a comparable volume of steel. The alloying elements of the cast sheet material are: 1.5 to 1.8 per cent silicium, 0.5 to 0.8 per cent manganese, not over 0.05 per cent each of sulphur and phosphorus. The thickness of the finished sheets ranges between 0.0197 and 0.0468 in.

The material is being used for roofing and machine fabricating and can be welded and bent 180 deg at a bending radius of 0.118 in. Adaptable to electrical appliances, its resistance is 3.5 times greater than that of steel sheet material.

ENGINEERS EARNED 8.6 PER CENT MORE IN 1956 . . . .

. . . than they earned in 1955 according to a survey of engineers and other professional employees made by the American Management Association. The majority of the companies surveyed said they gave salary increases to their technical and administrative personnel during the period of the survey. This 8.6 per cent over-all average increase for this group compares with a 4.5 per cent increase for the previous year. The percentage rise in engineers' salaries from 1955 to 1956 is higher than that shown for any of the other executive and specialized groups. The report showed that engineers with less than one year of experience are earning a median salary of $5300 a year, regardless of the area of specialization. The next higher category of engineers, with experience ranging from one to three years, has a median salary of $6500 a year. The survey is part of a continuing series to report salary ranges for specific "exempt" jobs in business and industry (exempt from compulsory overtime penalty pay provisions of the Fair Labor Standards Act).

LOW WATER ABSORPTION OF A NEW FRENCH PLASTIC. . . .

. . . makes it a good electrical insulator in the low and medium frequencies and voltages regardless of the surrounding conditions. Called Rilsan, the plastic is of the polyamides class and absorbs less than 1 per cent of water. Most polyamides absorb up to 10 per cent. The melting point is 364 F, and the plastic will stand a prolonged temperature of about 285 F without ill effects. For continuous operation, the maximum temperature should not exceed 212 F, and the minimum

(*Continued on page 13*)

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Specialties, Inc.
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CHICAGO 47, ILLINOIS

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WORM GEARING • RACKS • THREAD GRINDING

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G. S. research has now *overcome vibration and flutter* in Small Gearing for many vital applications. G. S. PATENTED GROOVES, as pictured here, successfully insulate vibrations of worm and gear teeth from reaching the shaft. Ultra smooth, *noiseless* operation is more than ever assured by the use of Bakelite Gears. ★ Whatever YOUR Gearing problem, you can depend upon G. S. research and engineering to lend powerful aid in reaching a successful solution. Here, you can, *without cost or obligation,* draw upon experience gained through 40 YEARS of specialization in the design and mass production of better Small Gearing exclusively. Send drawings and particulars today. Get the ONE best and most economical application for the job!

SEND FOR FREE *6-page Small Gearing Guide. It describes 80 types and applications. Contains useful charts . . a valuable aid to anyone interested in Small Gearing. Use company letterhead, please. No obligation, of course. Write today!*

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40 Years of Specializing in Small Gearing!

SAVE SPACE AND COSTS...TRANSMIT UP TO *OR OVER*

1000 HP WITH THE NEW

Gilmer XX HEAVY DUTY

1¼" PITCH

"TIMING"® BELT DRIVE

TO HELP YOU COMPARE a Gilmer *XX Heavy Duty* "Timing" Belt drive with the four other common forms of power transmission of equal capacity, a power transmission engineer offers his recommendations based on published application and load ratings, for the following:

A 300-HP drive (at 1160 rpm.) including application factors
3.00: 1 speed reduction
Approximately 50" center distance

Here, complying with minimum pulley sizes and other practices commonly observed, are his recommendations (with approximate comparative cross sections of space occupied by each drive):

"TIMING" BELT DRIVE
Belt: XXH "Timing" Belt 10" wide by 160" P. L.
Motor Pulley: 9.549" P. D. (24-groove) 1¼"-pitch
Driven pulley: 28.648" P. D. (72-groove) 1¼"-pitch
Belt speed: 2900 feet per minute

V-BELT DRIVE
Belts: 10 Super Service "D"-Section V-Belts (DP-225)
Motor pulley: 18.0" P. D. x 10 D-groove, 14¾" wide
Driven pulley: 54.0" P. D. x 10-groove, 14¾" wide
Belt speed: 5380 feet per minute

GEAR DRIVE
Herringbone gear speed reducer with 3:1 ratio. (A typical reducer of required capacity weighs 1440 lb., measures 33" long, 26⅜" high and 19" wide.)

ROLLER CHAIN DRIVE
Chain: #80-8 (8 strands) 1"-pitch x 152 pitches
Motor sprocket: 7.979" P. D. (25 teeth)
Driven sprocket: 23.880" P. D. (75 teeth)
Chain speed: 2380 feet per minute
(Requires Type #3 lubrication with oil-tight case for sump pump)

FLAT BELT DRIVE
Belt: 21" wide x 8-ply x 18' 4" long
Motor pulley: 18" O. D. x 23" wide
Driven pulley: 54" O. D. x 23" wide
Belt speed: 5380 feet per minute

In cost and in weight the "Timing" Belt drive also has a big savings advantage. Ask your NYB&P-Gilmer Distributor for the figures.

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NEW YORK BELTING & PACKING CO. 1 Market St., Passaic, N. J.

America's Oldest Manufacturer of Industrial Rubber Products

—65 F. Electrical insulation resistance after submersion in water for 24 hr is 1 x 10^{13} ohms/cm; after 4 days at 80 per cent relative humidity, 3 x 10^{14} ohms/cm. Dielectric strength for Rilsan 0.120 in. thick is 425 v/mil; 0.020 in. thick, 1000 v/mil; and 0.004 in. thick, 1600 v/mil. In the unstretched condition, like a molding or a cable coating, the plastic has a toughness of 10,000 psi, a maximum elongation of 200 per cent, and a resistance to compression of 16,000 psi. Coefficient of friction is 0.11 to 0.18. Rilsan's molding characteristics are good, and the material is adaptable to most injection machines. It may be extruded in tubes, sheets, or tapes, transparent or colored. Thermal conductivity is 7 x 10^{14} cgs. The plastic is manufactured by Organico, Paris. U.S. representative is Rilsan Corp., The John Hancock Bldg., Boston 16, Mass.

ELECTRODEPOSITED PROTECTIVE COATINGS ON TITANIUM. . . .

. . . is expected to expand the metal's high temperature applications. The process, as developed by the National Bureau of Standards, Washington 25, D. C., involves the forming of a titanium fluoride film on the metal surface, electroplating with chromium, and heat treating the plated specimen at 1475 F. As poor adhesion of the coating is blamed on an oxide film on the titanium, the test specimen was thoroughly degreased and cleaned, then dried and suspended in a solution of hydrofluoric and acetic acids for 10-15 min. A 60 cyc. current is passed through the specimen for another 10 min. It is then rinsed and transferred to a conventional chromium plating bath for plating at 185 F and a current density of 120 amp/cm^2. The film contained 37 per cent titanium and 54 per cent fluorine. Adherence of the coating is improved by heat treating the plated specimen for two minutes at 1475 F in an inert atmosphere. The bond strength of the heat treated specimen ranged from 4000 to 18,000 psi. In all cases fracture occurred in the chromium plate and not between the two metals. Similar procedures for depositing nickel and copper on titanium have been tried, but the deposits have not adhered as well as chromium and have frequently blistered.

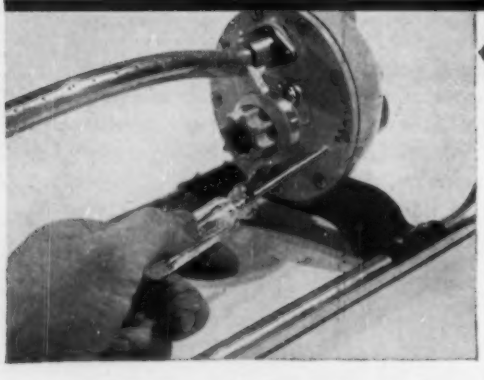
AND IN ADDITION . . . .

. . . Research volume at Armour Research Foundation was $1-million more in the 1955-1956 fiscal than during the previous year; a record 691 programs were conducted during the year, with 393 projects for industry and 298 for government . . . . A special anti-radioactive lubricant for control mechanisms in nuclear reactors has been reported by Rocol Ltd., Swinnington, Leeds., England; a molybdenum disulphide based varnish, it solidifies to form a thin film over the heated parts, and gives a good lubricated surface for the moving parts while protecting it from CO_2 corrosion. . . . Arthur D. Little, Inc., Cambridge, Mass., plans to enter the high temperature field, and is building a solar furnace for this research; expected working temperature is around 3500 F. . . . Especially developed for use in coloring plastics, particularly polyvinyl chloride, a new organic red pigment is reported to have several advantages over most inorganic red pigments; it has good fastness to light and heat, even when used in the low concentrations needed to make tint transparencies; called Irgalite Red HGL and made by the Geigy Co., Rhodes, Middleton, Manchester, England, the pigment cannot be used in rubber compounds. . . . The University of California at Los Angeles is the site of the first university computer center devoted primarily to the study of complicated business-management problems; located on UCLA campus, the Western Data Processing Center will be used by business people and students from universities in 11 western states and Hawaii; the Center was made possible by a series of gifts from IBM, including a 705 Electronic Data Processing Machine.

Investigate the assembly savings made possible by P-K® self-tapping screws

Because P-K Type A Self-tapping Screws have clean, deep slots and sharp gimlet points . . . and because they are consistently uniform, Reznor Mfg. Co. enjoys important savings in the assembly of their gas heaters.

To hold the plastic handle halves of their Instant Heat Soldering Irons together, The Lenk Mfg. Co. specifies P-K Type F Self-tapping Screws. No need for a separate tapping operation. Production is increased and costs reduced—thanks to P-K Screws.



Melnor Industries, Inc. (formerly Melnor Metal Products Co.) puts assembly strength into their famous "Swingin' Spray" oscillating lawn sprinkler by fastening zinc and aluminum parts with P-K Self-tapping Screws—7 Phillips Head Type Z and 18 Type F. They start right . . . drive right . . . and stay tight.

PARKER-KALON DIVISION, General American Transportation Corporation
Manufacturers of Self-tapping Screws, Socket Screws, Screwnails, Masonry Nails, Wing Nuts and Thumb Screws

PARKER-KALON® fasteners

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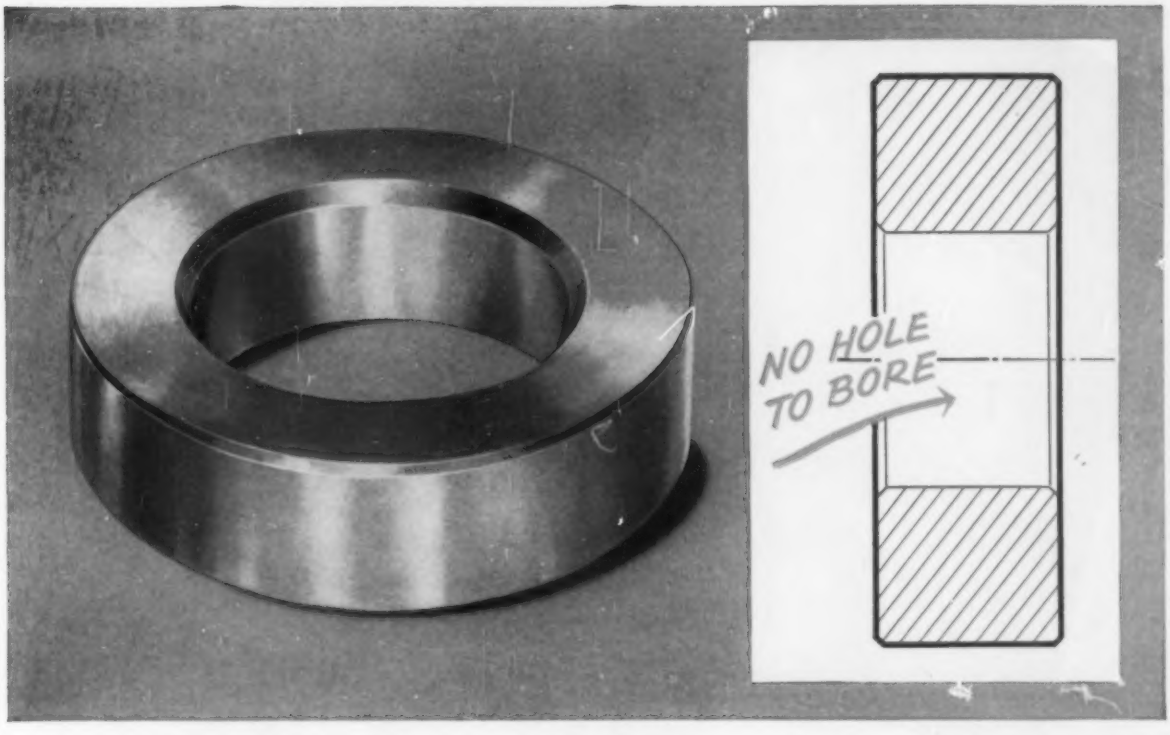


Steps up gear blank production 300% by switching from bar stock to TIMKEN® steel tubing

AN engine manufacturer felt that his gear blanks were costing him too much to make. The center hole had to be bored out of solid bar stock. It took a whole hour to turn out 29 blanks. And a lot of steel was wasted in the process.

So the manufacturer discussed his problem with metallurgists of the Timken Company, experts in fine alloy steel. After study they recommended a change in production methods together with a switch to Timken® seamless steel tubing in place of bar stock.

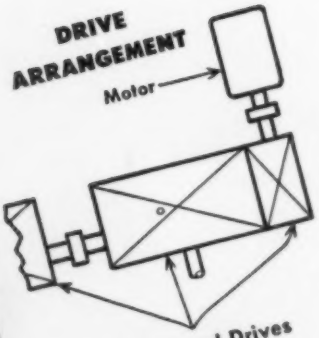
With Timken seamless steel tubing, the center hole is already there. It doesn't have to be bored out. Finish boring was the engine maker's first production step. And with Timken steel tubing his gear blanks are now being turned out at 120 to 130 an hour—an increase of 300%.

Machining costs have been cut by more than half. And because the center hole is "built-in", no steel is wasted.

The files of the Timken Company contain records of hundreds of problems that have been solved by Timken fine alloy steel. If you have a tough steel problem, why not bring it to us? Wire, write or phone The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS TUBING



3-Cleveland Drives

Note the small overhung reducer is transmitting power to both of the larger Clevelands—a compact but powerful drive arrangement.

CLEVELAND-driven scarfer dresses beryllium-copper slabs

SPECIALLY designed to handle beryllium-copper alloys, this automatic rotary scarfer puts smooth, clean surfaces on bar stock ranging from 5/16" to 1⅛" in thickness, up to 14" wide.

Drives are Cleveland Worm Gear Speed Reducers, actuating both the rotary tooth cutter and the bar-drawing mechanism. Power from the motor is transmitted at a uniform, predetermined rate, ensuring precision in product dimensions and economy of machine operation. Furthermore, the compactness of the right-angle Cleveland drive arrangement permits important space saving in the equipment installation.

Wherever you need to operate a machine efficiently, smoothly and economically, count on using a Cleveland. Let us send you Catalog 400 and the name of our nearest representative who is prepared to help you select Clevelands best fitted to solve your transmission needs. The Cleveland Worm & Gear Company, 3279 E. 80th St., Cleveland 4, O.

Affiliate: The Farval Corporation, Centralized Systems of Lubrication. In Canada: Peacock Brothers Limited.

CLEVELAND
Worm Gear
Speed Reducers

This NEW Magnetic Counter is EASY to Reset...

Added Evidence that —

Everyone Can Count on VEEDER-ROOT

Designed for panel mounting where remote indication is required, this electrically operated counter is a compact package 5.5″ long, 2.1″ wide, 2.7″ high. Capacity: 1,000 counts per minute. Power consumption, 8 watts. Stocked in 110 and 220 AC and DC. Easy to reset, except when locked . . . then the sturdy tumbler-lock* puts the damper on tampering. Yet one turn of the key resets all 6 figures to zeros.

This new Magnetic Counter is one of the thousands of Veeder-Root standard and special counters . . . electrically, mechanically and manually operated . . . in daily use throughout the world in industry, business, science and medicine. You, too, can count on Veeder-Root . . . to help you count anything you need.

*National Lock Co. Lock No. 68-4837, Key D-428

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VEEDER-ROOT
"THE NAME THAT COUNTS"

Craftsmanship of the 20th Century

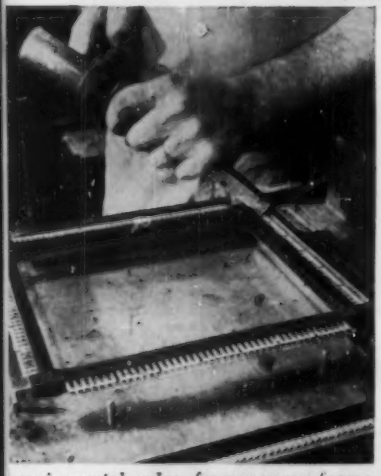
MONSANTO

Today's industrial designers work closely with plastics engineers in solving many complex design and production problems. Here is a graphic example of contributions being made by custom-molding craftsmen.

Resinox® thermosetting plastic helps IBM electronic "brains" perform amazing feats of "memory"

DESIGN OBJECTIVE IBM's blue-prints for its new 704 and 705 Electronic Data Processing Machines called for special frame assemblies to house thousands of tiny magnetic "memory" cores, strung on grids of coordinate wires, which attach to terminal inserts in the sides of the frames.

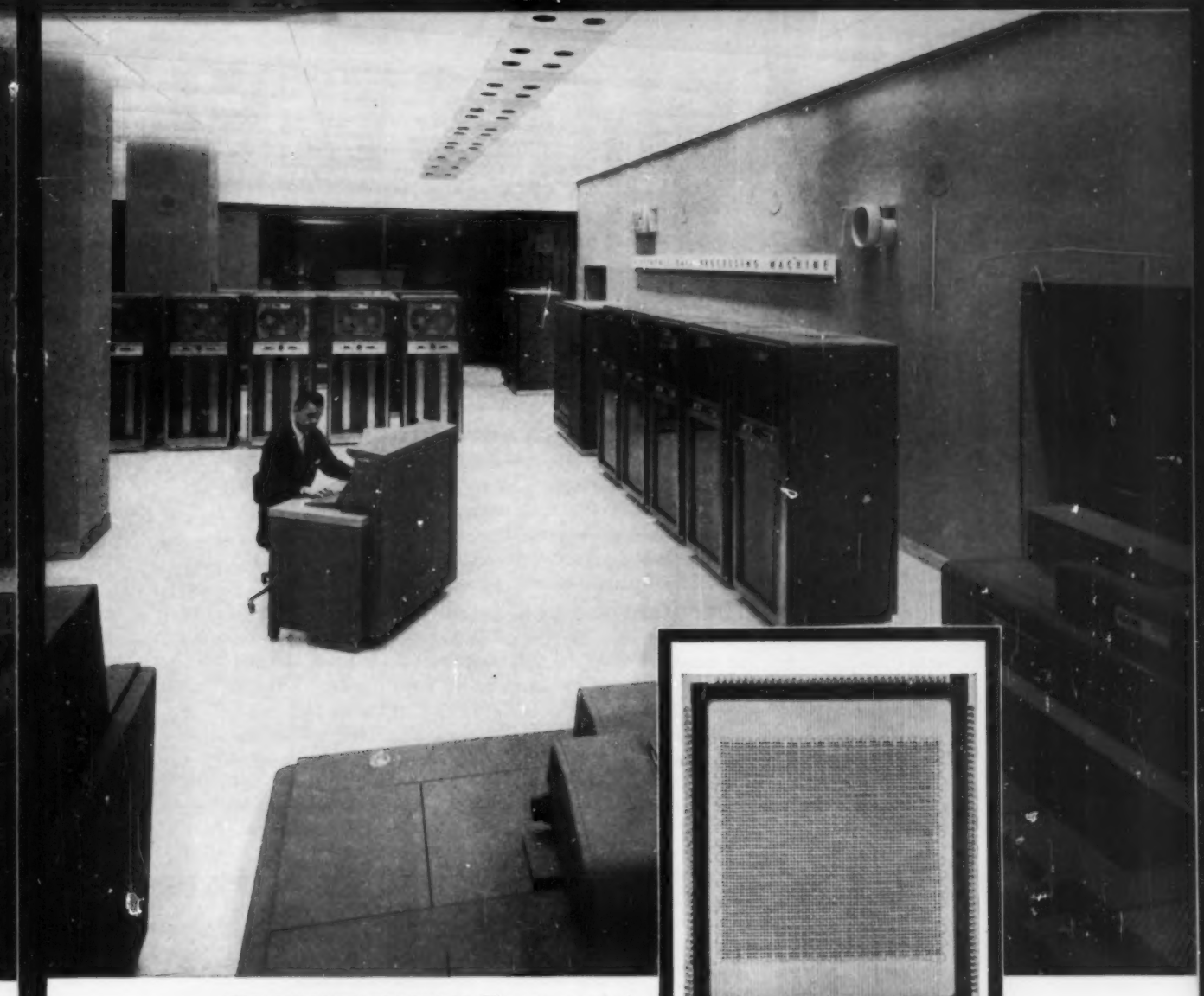
MATERIAL SPECIFICATIONS In setting up specifications for the frame material, IBM design engineers had to consider many factors. For one thing, since the memory frames were to be stacked 35 and 36 high, no frame could deviate in flatness beyond .030 inches in the 10 inch frame length. Shrinkage also must be predictable within fine limits. Rigidity was another requirement. Although light in weight, the frame was expected to withstand up to a pound's pull from each of the wires—and there are 68 grooves for wires on the short side, 86 along the length! Next, production called for the 308 terminal posts set in the edges of each frame, to be hot-dipped in a lead-tin mix at 550°F. without distortion of the plastic. And finally, of course, the frame material must possess superior dielectric strength and other electrical properties.

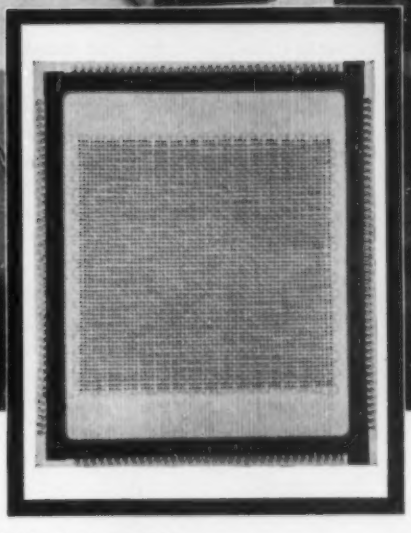


...ossening metal wedges from memory frame.

PRODUCTION ENGINEERING Specialty Insulation Manufacturing Company, Inc., Hoosick Falls, N. Y. was awarded the job of molding the frames. SIMCO engineers, after long thorough investigation, selected Resinox 3700 as the frame material. Less expensive than other materials tested, this Monsanto thermosetting plastic was easier to handle, easier to transfer mold. Its electrical characteristics passed IBM's tests. It possessed excellent dimensional stability, stayed flat, rigid. Resinox 3700 had an extremely low predictable shrinkage. Its heat resistance permitted hot dip soldering.

The frames are being molded of Resinox 3700 in conventional 100-ton transfer-molding presses. A molding temperature of 310°F. is used. Molding time is two minutes. Loading 9 oz. of Resinox in the press is accomplished by first preforming the powder into six 1" x 2" pills, then preheating the pills to 275°F. in an electronic preheater for 10 to 15 seconds.





THE FINISHED PRODUCTS These two new and advanced IBM Electronic Data Processing Machines, which can remember up to 40,000 letters, numbers or symbols and can recall facts in a few millionths of a second, are solving many highly complex business and scientific problems including ones connected with top defense projects. One machine, for example, is making high speed calculations in jet engine design. Another is being installed for use in nuclear weapon development. A third is involved in the design of gas turbines.

The contributions that plastics custom molding craftsmen have made in the development of this giant electronic "brain" are being repeated in hundreds of cases in all phases of industry. The skills and services of these 20th Century craftsmen are available to every manufacturer designing for greater efficiency and lower costs. As a major supplier of plastic resins, Monsanto is in a position to direct you to custom molders who can bring long experience and detailed knowledge to bear on your problems. Write to Monsanto Chemical Company, Industrial Applications Dept., Room 911, Springfield 2, Mass.

MONSANTO

RESINOX®

Investigate Monsanto's completely balanced line of phenolic plastic compounds developed for particular applications and sold under the trade name Resinox.

how ARMASTEEL wider scope of

NEW PRODUCT DESIGNS POSSIBLE . . . Due to their unusual physical properties, high machinability ratings, and wide latitude of design, ArmaSteel castings are replacing other materials in today's products. Being a casting material, ArmaSteel can be formed in shapes too complex for the forging process. With ArmaSteel castings, low draft angles, intricate coring, and close dimensional tolerances are possible. Less stock remains to be machined. High tensile strength, damping qualities, and other physical and chemical characteristics are also major factors in ArmaSteel's popularity among product design engineers.

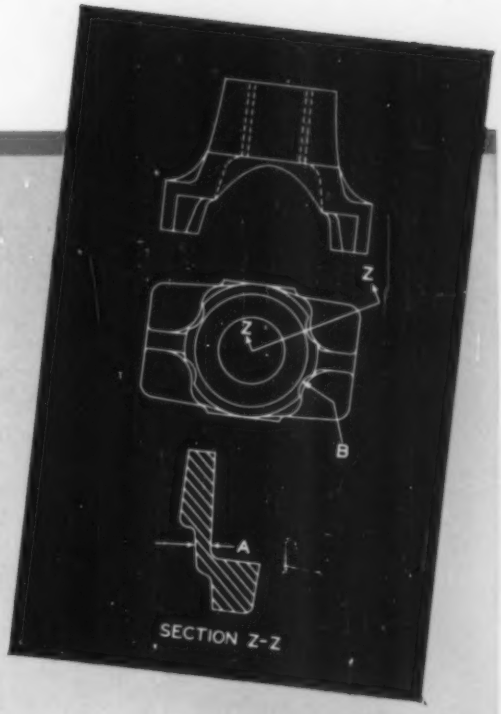
ARMASTEEL IS A PEARLITIC MALLEABLE IRON, possessing many of the physical characteristics of forged low-carbon steel. Because of carbon nodules in the pearlite matrix, the machinability of ArmaSteel castings is 58% better than S.A.E. 1040 steel and compares favorably with S.A.E. 1112. ArmaSteel is produced in three ranges, with tensile strengths from 70,000 psi to 100,000 psi, yield strengths from 48,000 psi to 80,000 psi, and elongations (in 2") from 2% to 4%. Because of these excellent properties, and because it can be either sand cast or shell cast, ArmaSteel provides improved parts for many products, at the same time that it lowers costs. On these pages are two case histories of products that have benefited from ArmaSteel castings . . . perhaps your product can benefit too.

CAST ARMASTEEL IMPROVES AN AUTOMOBILE DIFFERENTIAL CASE

This case forms the support for the driving gears in an automobile. The demands made of such a part are that it be of high strength, that it have the least possible deflection, and that—because it is part of the car's unsprung weight—its weight be held to a minimum to help the riding characteristics. The part must be cast because it is impossible to forge the internal cavity.

ARMASTEEL 86M MET ALL THESE DEMANDS. It has a tensile strength of 70,000 psi, a yield strength of 48,000 psi, and a Brinell Hardness No. of 163-207. Deflection is very low, and ArmaSteel absorbs vibrant energy, thus contributing to quiet operation. The cast ArmaSteel part also allowed the manufacturer to eliminate thrust washers on the pinion gear bearings, reducing costs.

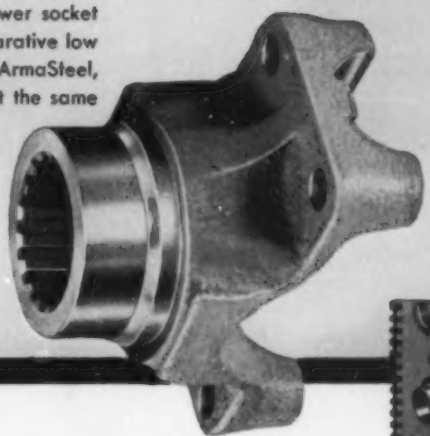
castings allow new and much design



CAST ARMASTEEL REPLACES FORGINGS IN THIS COMPANION FLANGE BECAUSE OF SPACE LIMITATIONS

This part was formerly a medium carbon steel forging. During a re-design of the unit, it was impossible to get the desired strength by enlarging the part, because of design limitations. It became apparent that the draft angles necessary in the forging would not allow proper thickness of metal at point "A". Only a casting could achieve the low draft angles needed, and only a high strength material could meet the design requirements.

CASTINGS OF ARMASTEEL 84M PROVIDED THE ANSWER. ArmaSteel 84M has an ultimate tensile strength of 100,000 psi, and a yield strength of 80,000 psi. ArmaSteel parts tested showed a long fatigue life and minimum deflection under the extreme stress involved. In addition, castings offered a reasonable cost per piece, excellent machinability, and uniformity in production lots. In broaching the spline in the center hole, the manufacturer found that ArmaSteel castings resulted in greatly improved broach life. Draft angles were reduced to 2°, which allowed sufficient clearance (point "B") for the power socket wrench assembly operations. Thus, due to the comparative low cost of castings and the reduced machining costs of ArmaSteel, the manufacturer enjoyed an overall saving and at the same time solved his design and assembly problems.



66

For further information on physical properties and applications of ArmaSteel, write for our complete catalog. Descriptive literature is also available on our shell mold and sand casting processes.

CENTRAL FOUNDRY DIVISION · GENERAL MOTORS CORPORATION

CENTRAL FOUNDRY DIVISION

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manager
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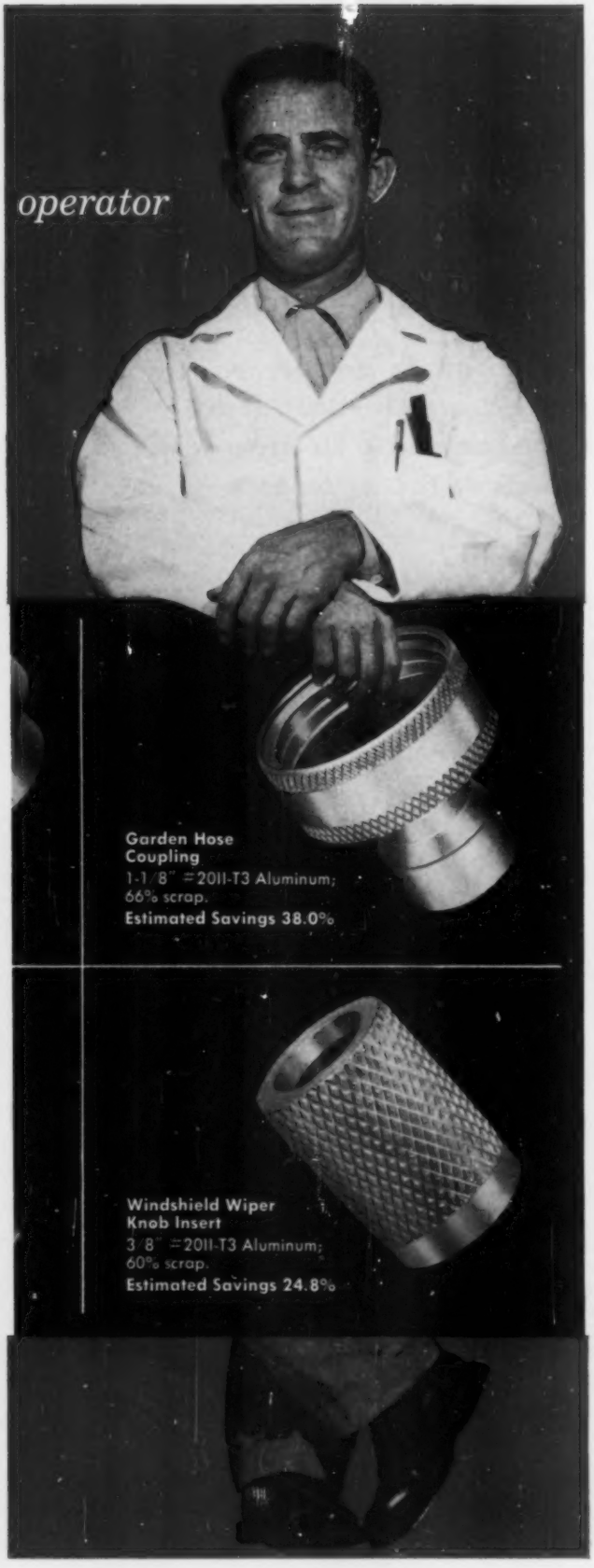
Pencil Bushing
7/32" ⌀ 2011-T3 Aluminum;
75% scrap.
Estimated Savings 46.0%
Spacer for Clock
3/16" ⌀ 2011-T3 Aluminum;
20% scrap.
Estimated Savings 49.0%
Ferrule Sleeve from
Hydraulic Brake Fitting
5/16" ⌀ 2011-T3 Aluminum;
50% scrap.
Estimated Savings 47.0%
Fitting
5/16" Hex ⌀ 2011-T3 Aluminum;
55% scrap.
Estimated Savings 44.0%
Spacer for Clock
7/32" Hex ⌀ 2011-T3 Aluminum;
65% scrap.
Estimated Savings 48.6%
Pencil Point
Bushing
1/4" ⌀ 2011-T3 Aluminum;
65% scrap.
Estimated Savings 40.5%



ASK ALL THREE

why these eight screw machine parts were converted from brass to Kaiser Aluminum...

Operators say "easy to machine"...

Designers say "exceeds requirements"...

Management says "saves money."

Let us assist you in designing lower cost screw machine parts with...

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For complete information and expert assistance, call one of our many distributors, or look for our local number in your classified telephone directory.

Kaiser Aluminum & Chemical Sales, Inc., *General Sales Office,* Palmolive Bldg., Chicago 11, Illinois; *Executive Office,* Kaiser Bldg., Oakland 12, California.

See "THE KAISER ALUMINUM HOUR." Alternate Tuesdays, NBC Network. Consult your local TV listing.

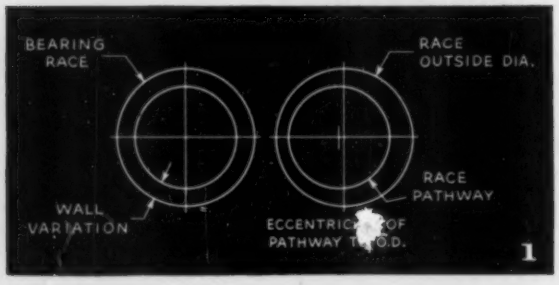
The Inside Secrets of Smoother Performance

How HYATT quality controls assure race concentricity, roller diameter uniformity and other internal essentials of smoother, longer-lived cylindrical roller bearings . . .

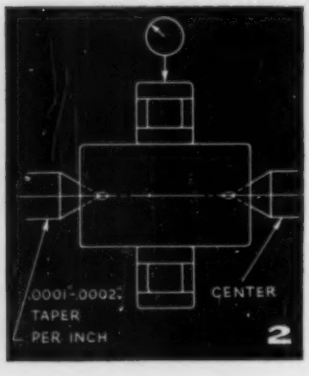
The running accuracy and smoothness of a roller bearing is governed primarily by its internal dimensions and clearances. The most important of these are:

1. CONCENTRICITY OF RACE DIAMETERS

Eccentricity of race diameters is usually interpreted in terms of *wall variation*, Figure 1, on the individual components and in terms of *radial run-out* on the assembled bearing. The



assembled bearing is usually mounted on an arbor, Figure 2, having a slight taper (.0001″ to .0002″ on the diameter per inch of length) and the radial run-out indicated as shown. The radial run-out is the difference between the minimum and maximum readings obtained when rotating the outer race one revolution with the arbor stationary for outer race radial run-out, or rotating the arbor one revolution with the outer race stationary for inner race radial run-out.

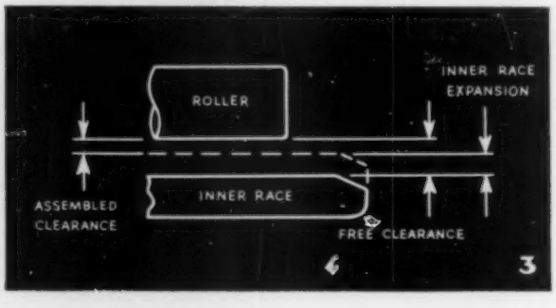


2. UNIFORMITY OF ROLLER DIAMETERS

Another factor governing running smoothness is *roller diameter uniformity*. This is usually obtained by segregating the rollers into diameter variation classes of .00005″, .0001″, or .00015″, depending on the bearing size and the nature of the application, and assembling only rollers of the same group into a given bearing. Gauging for this segregation necessarily rejects excessive taper.

Uniformity of roller diameters is important for another purpose. It provides the user with a bearing in which the internal diametral clearance is controlled within the closest possible limits. The rollers are matched with races which are segregated for pathway size in a fashion similar to the rollers, usually to twice the diameter limits of the rollers. The internal clearance can thus be manipulated at will by combining various diameter classes of races and rollers; but once a particular range is selected, it will remain constant within the combined limits of the roller and race pathway diameter limits. Here, again, a tapered condition of the race pathway is automatically rejected.

Obviously, the internal clearances of commercial bearings must be standardized for the practical reasons of cost and availability, but the clearance values have been so selected that under the specified fits the *running* clearance is at the most desirable minimum, depending on bearing type and size. Figure 3 (magnified).

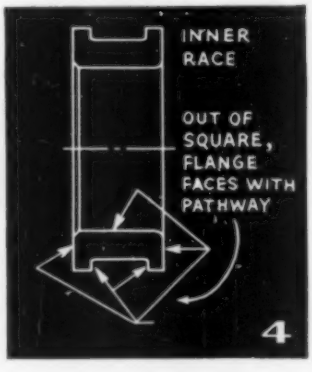


Checking wall variation, flange run-out and race end squareness on combination gauge.

3. SQUARENESS OF ROLLER ENDS AND FLANGE FACES

One other tolerance that contributes to the running efficiency of HYATT Hy-Load Series Bearings of the flanged race type is the *squareness of roller ends with roller diameters* and the *squareness of flange faces with the race pathways.*

Flanged race bearings are commonly used for locating shafts laterally and for running conditions of light and intermittent thrust load. For best operating results, the ends of the rollers must be flat and square with the diameter within a matter of tenths. The lateral clearance between the roller and the race shoulders must also be held to a minimum. This means close tolerances on roller length and race pathway width, and the flange face, Figure 4, must be square with the roller pathway. When all these conditions are satisfied, there will be no tendency for the rollers to skew and raise the operating temperature of the bearing, nor will there be any unusual force on the separator or cage with a tendency toward wracking and noisy operation.



The *side run-out* of the individual races or the *out-of-square* of the ends with the fitting diameters is also important, especially in applications where a number of parts are held together endwise and where the pressure might be sufficient to tilt the race, creating a condition of excessive taper on the roller pathway with consequent roller skewing and the development of excessive heat and noise.

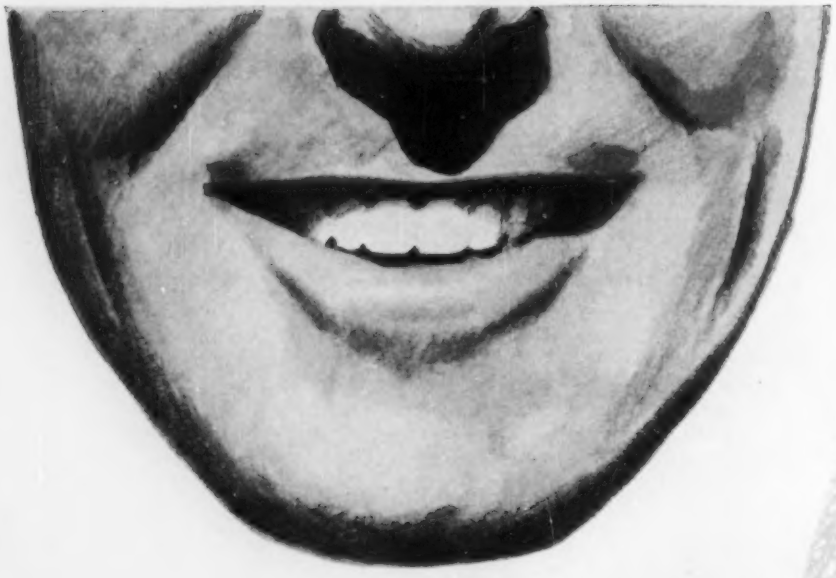
All these internal dimensions and clearances are so carefully controlled that HYATT Hy-Roll Bearings have built an unsurpassed reputation among design engineers for exceptionally long, smooth and trouble-free performance.

YOU WILL FIND MORE DETAILS

in HYATT General Catalog No. 150, or your nearby HYATT Sales Engineer will gladly help you choose the type best suited to your design requirements. Remember, HYATT is America's first and foremost maker of cylindrical roller bearings. Hyatt Bearings Division of General Motors Corporation, Harrison, New Jersey.

HYATT *HY-ROLL BEARINGS*
FOR MODERN INDUSTRY

GM GENERAL MOTORS



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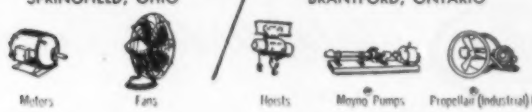


Motors | Fans | Hoists | Moyno® Pumps | Propellair® (Industrial) Fans

New Republic

REPUBLIC NYLOK NUTS offer advantages similar to those of Nylok bolts. They can be assembled from either end with hand or power tools, and lock tight wherever wrenching stops. Holding power is not affected by vibration. "Plastic memory" of nylon pellet gives Nylok nuts excellent adjustment and re-usability characteristics.

REPUBLIC

REPUBLIC STEEL

World's Widest Range of Standard Steels

Self-Locking Nylok Bolts

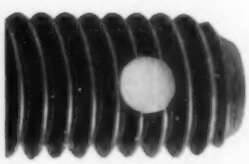
Provide Single-Unit Answer to Vibration, Liquid-Sealing and Adjustment Problems

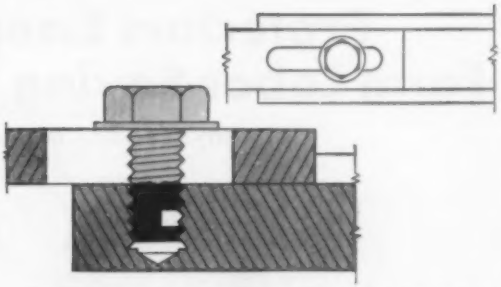
If your bolted assembly must be vibration-proof, liquid-tight or adjustable—Republic Self-Locking Nylok® Bolts are your best fastener selection. You simply align parts to be fastened and turn Nylok bolt into threaded hole. A positive lock is provided, whether or not the unit is seated.

In addition, use of Nylok bolts eliminates lost motion of assembling extra locking devices or expensive wiring. They can be hand wrenched or power driven to minimize fastening time—a tremendous asset in high-volume production runs.

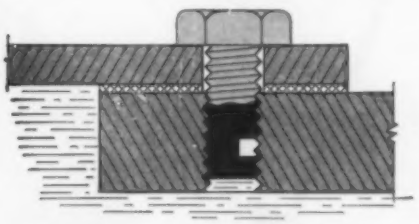
Locking is accomplished by means of a permanent nylon insert in the body of the bolt. This pellet wedges opposite mating threads together to form a vibration-proof lock. There is no damage to threads or seating surfaces, and the insert's resiliency allows fasteners to be adjusted and re-used repeatedly. Further, when properly seated, the nylon insert effectively blocks fluid flow around the helix of the threads. Even relatively soft materials can be locked to a threaded member using Nylok bolts.

When you specify Republic Nylok Bolts you secure the double protection of Nylok locking plus Republic quality, built into each fastener from raw ore to finished product. To find out how you can take full advantage of this ideal combination, contact your Republic representative. Or mail the coupon for further information.

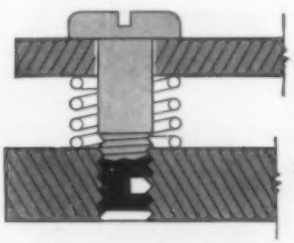




ADJUSTMENT problems like this movable plate are readily solved using Nylok bolts. The nylon pellet allows bolt to be backed off and wrenched tight time after time, without damage to threads, seating surfaces or holding power. Unaffected by age, immune to fungus, pellet won't dry out or shrink.



LIQUID SEALING properties of the Nylok bolt are demonstrated here. Nylon pellet, seeking to regain its original shape, effectively interrupts space between non-loadbearing surfaces of mating threads. Escape of fluid along helical thread path is blocked. Nylon's resistance to moisture and ordinary solvents assures permanence of seal.



VIBRATION has no effect on the locking characteristics of Nylok bolts, even when not wrenched tight as shown here. Secure grip is provided by nylon pellet permanently imbedded in fastener body. Continual pressure of resilient nylon forces tight metal-to-metal lock between mating threads opposite the pellet.

STEEL

and Steel Products

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Dept. C-2704
3150 East 45th Street,
Cleveland 27, Ohio

Please send me further information on Republic Nylok Bolts and Nuts.

Name_____ Title_____

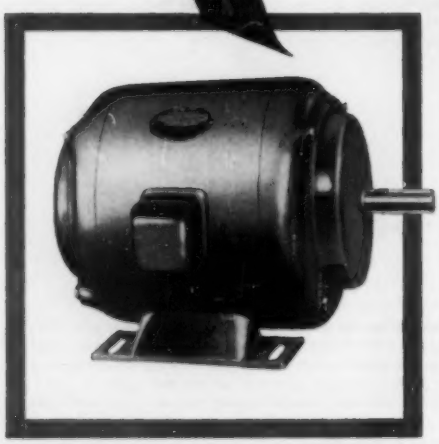
Company_____

Address_____

City_____ Zone_____ State_____

"KLIXON Protectors Essential for Farm Labor-Saving Equipment,"

. . . Says Leading Manufacturer



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METALS & CONTROLS CORPORATION
SPENCER THERMOSTAT DIVISION
3801 FOREST STREET, ATTLEBORO, MASS.

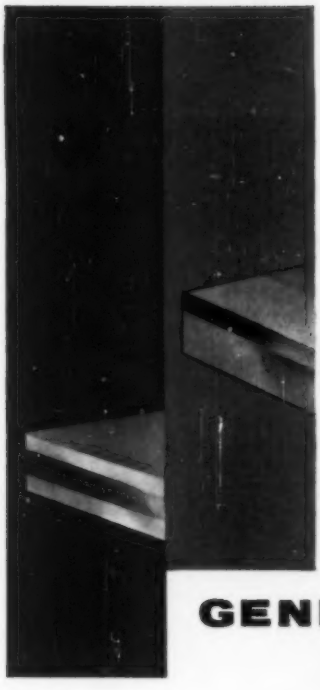
Since 1883 Starline has been building farm labor-saving machinery such as barn cleaners, milking stalls, and hay carriers. They know from long experience the value of Klixon Protectors . . . protection that produces maximum motor capacity safely under any overload condition.

Talking about its new Portable Barn Cleaner, Starline says: "*These cleaners are used by farmers out in the country where there is always the possibility of low voltage or some mechanical obstruction to the operation of the cleaner. We feel that it is essential that the motors on our barn cleaners, as well as our other electric labor-saving equipment, be protected by built-in Klixon Protectors.*"

Starline has, for many years, specified Klixon overload protection built into the motors powering ventilating fans, cattle feeders, silo unloaders and other farm equipment.

You, too, can keep motors in your equipment operating dependably, reduce service calls and repairs by specifying and using Klixon Protectors. The additional cost is low, pays for itself over and over by protecting against motor burnouts and unnecessary equipment shutdowns.

Now There's Something New! In addition to the famous Klixon Protector for single-phase motors, you can now get full protection engineered into 3-phase motors with a single, built-in Klixon Protector. For full details write for Bulletin MOPR1.



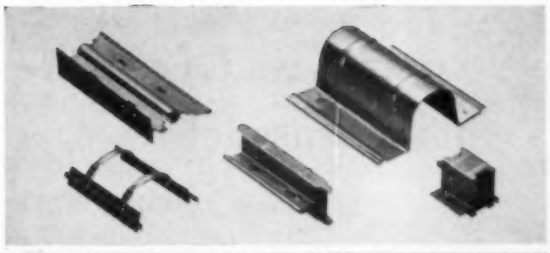
TWO METALS

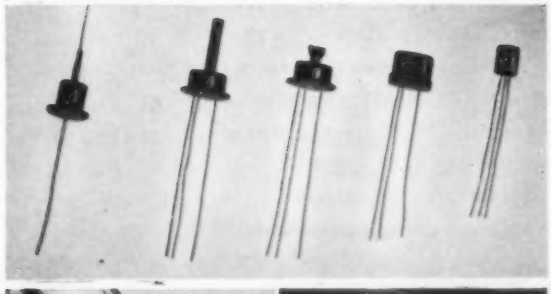
are often better than one...

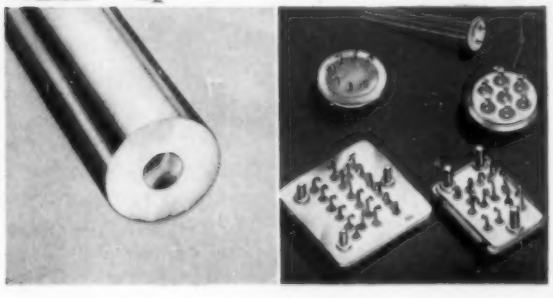
and

GENERAL PLATE *Clad metals*

for electronic uses are a case in point







Consider General Plate ALIRON®, ALNIFER®, and NIFER®, all preferred materials for vacuum tube plates. Offering improved performance with attractive cost savings, these General Plate Clad Metals are supplied in annealed coils ready to feed through your production tools. They form beautifully, conserving critical materials and producing more parts per pound. ALIRON and ALNIFER require no carbonizing — the matte finished aluminum blackens evenly during bombardment to provide a highly efficient radiating surface. For full details, write for Technical Data Bulletin 717C.

Or consider General Plate TIN CLAD NICKEL. Here's an improved material for transistor cradle supports. The layer of pure tin is unvarying in thickness and is bonded to a pure electronic grade nickel backing so completely that voids and contaminating inclusions are eliminated. This means perfect wetting during your transistor soldering operations — top transistor performance every time — lower soldering costs too! For full details, write for Technical Data Bulletin 708.

Or look to General Plate COPPER CORED 52 ALLOY WIRE for better glass-to-metal seals. With a 30% copper core you'll get up to three times the electrical and thermal conductivity over solid lead wires of the same size — or you can cut your solid lead wire sizes correspondingly, without reducing electrical ratings by using General Plate Copper Cored 52 Alloy Wire, and take a big step toward miniaturization in sealed terminal blocks and hermetic headers. For full details, write for Technical Data Bulletin 706.

To get the whole General Plate Clad Metal Story, write for our new general catalog, PR-700A, covering many other combinations in both base and precious clad metals — composite electrical contacts — TRUFLEX Thermostat Metals.

You can profit by using General Plate Clad Metals

Metals & Controls Corporation

GENERAL PLATE DIVISION

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With National Seals

Quality control isn't a myth— it's a crusade!

At National, quality control is based on the oil seal industry's most rigid manufacturing specifications. It begins with critical examination of raw materials. It includes constant checking of form tools and molds. It extends to exhaustive optical examination of all seal components by an exclusive process developed at National. (In this process, seals are cast and cross-sectioned, and an optical comparator used to show exact shape and position of every seal part, mounted on the shaft or unmounted.) And always, there are extensive and continuing operating and "leak" tests of finished seals.

For proved dependability, specify National seals. And for prompt, knowledgeable help on sealing problems, call your factory-trained National Seal engineer.

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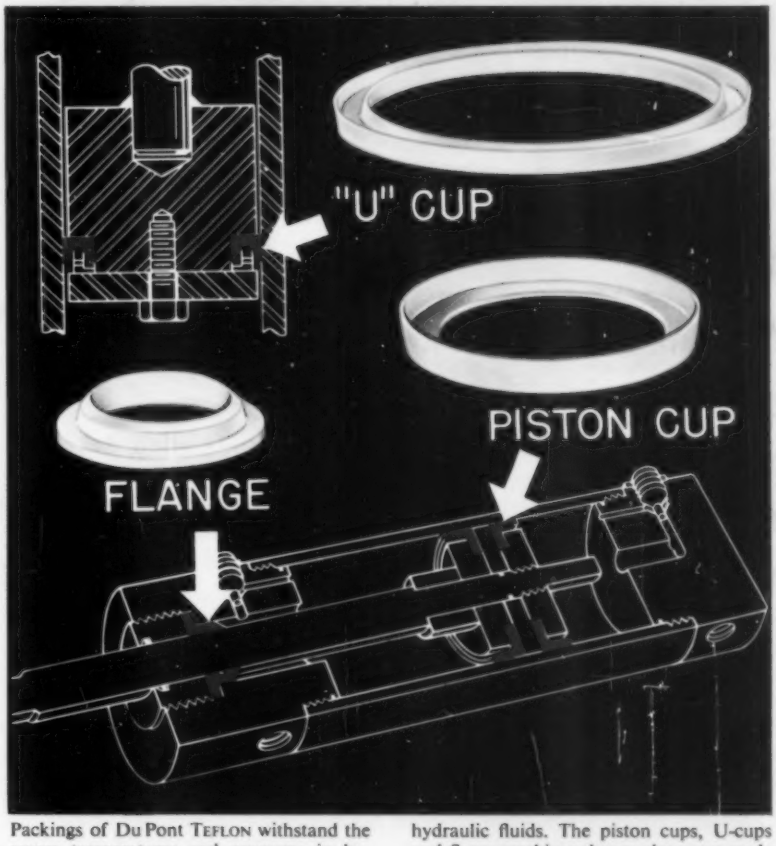
PRODUCT ENGINEERING NEWS
PROPERTY AND APPLICATION DATA
ON "TEFLON" TETRAFLUOROETHYLENE RESIN

TEFLON® offers design possibilities unmatched by any other single material

MECHANICALLY, TEFLON tetrafluoroethylene resin offers high impact strength and toughness. This durable material can be used at temperatures to 500°F., and displays excellent properties at very low temperatures. TEFLON is weather resistant. Sticky or viscous materials do not adhere to its surface. The low coefficient of friction of TEFLON (kinetic coefficients of 0.04 and under have been measured) often eliminates the need for lubrication.

ELECTRICALLY, the power factor of TEFLON is less than 0.0003 over the measured spectrum (60 cycles to 10^8 cycles). Volume resistivity exceeds 10^{15} ohm-cm. Dielectric constant is 2.0 over the range tested (60 cycles to 10^8 cycles). Water absorption (ASTM D570-42) is less than 0.01%. TEFLON readily provides continuous service at 500°F., exceeding requirements of Class H materials.

CHEMICALLY, TEFLON is completely unaffected by all chemicals normally encountered in commercial practice. Exceptions to this include attack by the alkali metals under certain conditions. At elevated temperatures and pressures, halogens and certain halogenated chemicals and solvents may affect it. Through the use of TEFLON tetrafluoroethylene resin, reduction of maintenance costs and downtime, as well as simplified design, have been achieved in many chemical installations.



Packings of Du Pont TEFLON withstand the severe temperatures and pressures in hydraulic cylinders. Components made of TEFLON tetrafluoroethylene resin do not harden, shrink or swell—are unaffected by hydraulic fluids. The piston cups, U-cups and flange packings shown above are made from Du Pont TEFLON tetrafluoroethylene resin by the Crane Packing Company, Morton Grove, Illinois.

TEFLON Can Now Be Cemented with conventional adhesives, owing to a new process. Good bonding strength can be achieved between the cementable TEFLON and wood, glass, steel, aluminum, copper, ceramics, plastics—in fact, any material on which commercial adhesives can be used.

Cementable TEFLON is now available in tape or sheet form. Tubing, cylinders, rods, and bars made of TEFLON are also obtainable with prepared surfaces.

Imaginative applications of Du Pont TEFLON have increased the efficiency of existing equipment. This versatile material provides new design opportunities.

OVER

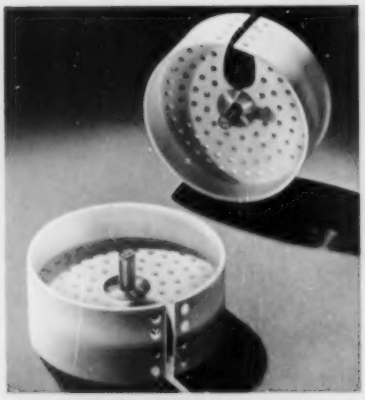
PRODUCT ENGINEERING NEWS

DU PONT

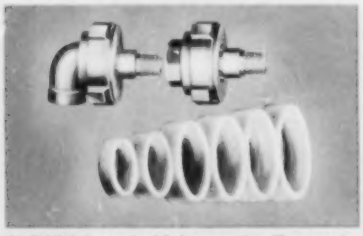
PROPERTY AND APPLICATION DATA ON DU PONT "TEFLON" TETRAFLUOROETHYLENE RESIN

NO. 1, 1961

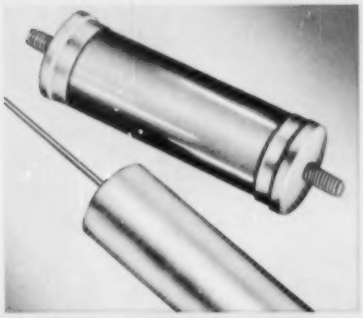
19 product



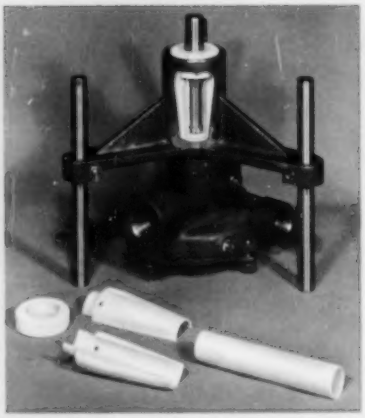
WATER METER PISTON of TEFLON assures accurate meter readings. The low coefficient of friction of TEFLON allows parts to move freely. Because TEFLON is used, no corrosion or build-up takes place in the piston holes or on the periphery to cause errors. (Manufactured by the John L. Doré Company of Houston, Texas.)



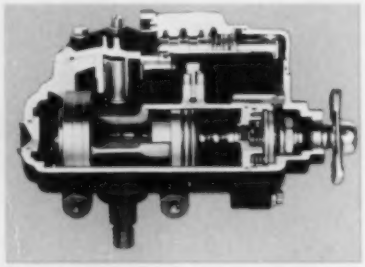
GASKETS for swivel joints employ TEFLON for long wear and trouble-free service. Gaskets maintain their seal under the most adverse conditions. They excel in steam service, perform uniformly over a wide temperature range without requiring lubrication. (Swivel joints by Barco Manufacturing Co., Barrington, Illinois.)



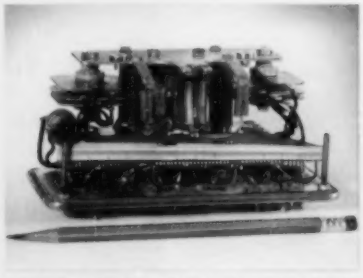
CAPACITORS of TEFLON for use in guided missiles and high-speed aircraft withstand temperature extremes from —90°F to 390°F. The use of TEFLON results in extremely high insulation resistance at rated voltages, and very low power factor at measured frequencies. (Manufactured by Condenser Products Division of New Haven Clock and Watch Company, New Haven, Connecticut.)



SUMP PUMP for chemicals employs a main bearing of TEFLON, eliminating auxiliary lubrication and the contamination of pumped chemicals by such lubricants. Bearings of TEFLON permit either chemical or steam sterilization, and withstand abrasion and chemical attack. (Manufactured by ECO Engineering Company, Newark, N. J.)

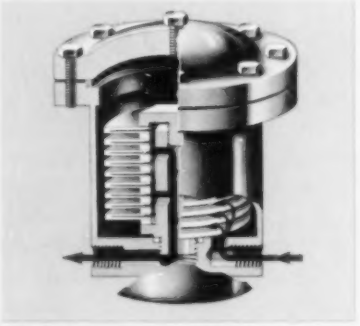


SEALS made of TEFLON reduce manual turning effort and wear in a leading power steering mechanism. TEFLON was selected for its toughness, low coefficient of friction, and exceptional thermal stability. (Seals of TEFLON manufactured by Garlock Packing Company, Palmyra, New York.)

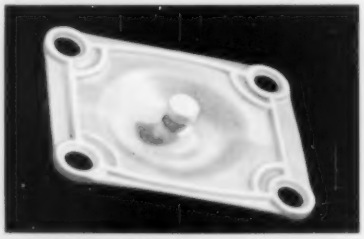


TUBING of Du Pont TEFLON is used as insulation in the compact Size 4 Regohm unit, used for the precise control of current, voltage or speed. TEFLON provides lasting protection, at extremes of temperature and humidity. (Regohm by Electric Regulator Corporation, Norwalk, Connecticut; tubing of TEFLON by Pennsylvania Fluorocarbon Company, Inc., Philadelphia, Pennsylvania.)

MECHANICAL SEAL, in pump for handling corrosive liquids and slurries, utilizes the resiliency and chemical inertness of TEFLON. The use of TEFLON as a shaft packing prevents leakage. TEFLON is also employed as a self-aligning wedge lock, which precludes rotation of the pump stator. (Manufactured by Chemical Power and Products, Inc., New York City, New York.)

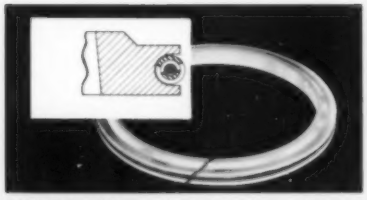


FILTER UNIT of porous TEFLON is a most effective filtration medium, removing particles as small as 3 microns from corrosive liquids, and 0.1 microns from gases. Filters of TEFLON permit high-capacity flow and can be cleaned with solvent. (Manufactured by Porous Plastic Filter Co., Inc., A Pall Filtration Company, Glen Cove, New York.)

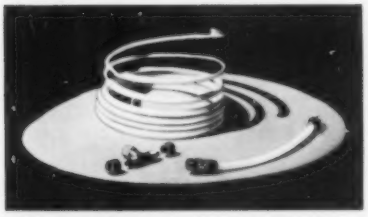


DIAPHRAGMS of TEFLON make it possible to control the flow of extremely corrosive, hard-to-handle fluids. Diaphragm withstands temperatures up to 400°F., or pressures to 100 psi. (Valve manufactured by Hills-McCanna Co., Chicago 18, Illinois; diaphragm of TEFLON molded by Raybestos-Manhattan Inc., Manheim, Pennsylvania.)

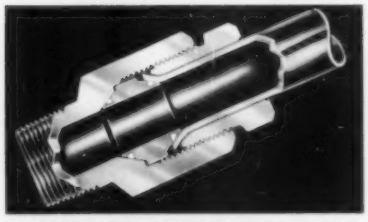
examples of improved design with Du Pont TEFLON®



SCRAPER RINGS of TEFLON keep dirt and other foreign matter away from O-ring seals in hydraulic retracting cylinders and actuators, control valves, and pneumatic equipment. These spring-loaded rings give unexcelled service at high operating temperatures. (Scraper made by Shamban Engineering Company, Culver City, California.)

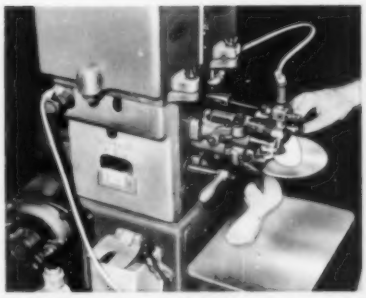


TUBING of TEFLON is exceptionally easy to position or to slide over electrical conductors because of its low coefficient of friction. Convenient to handle, tubings of TEFLON can be readily cut with a knife, bent and positioned by hand. Tubing shown above is manufactured by Halogen Insulator & Seal Corp., Franklin Park, Illinois.

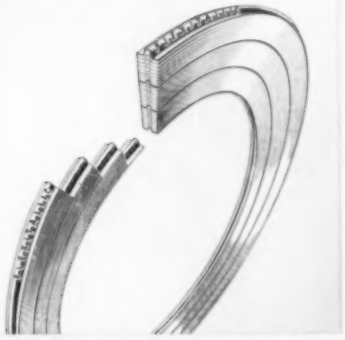


STAINLESS STEEL FITTINGS for flared tubing employ resilient seals of TEFLON which conform to surface irregularities as fittings are tightened. A leak-proof, vacuum-tight seal results, which is resistant to corrosive chemicals. ("Koncentrik" fittings manufactured by Special Screw Products Co., Bedford, Ohio.)

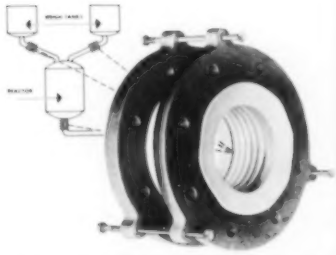
MINIATURIZED COILS show how small electronic components can be made by utilizing the unique electrical and mechanical properties of TEFLON. TEFLON has high volume resistivity, extremely low loss factor, even at very high frequencies, and low dielectric constant. (Wire used in the coils is manufactured by Hitemp Wires, Inc., Mineola, New York.)



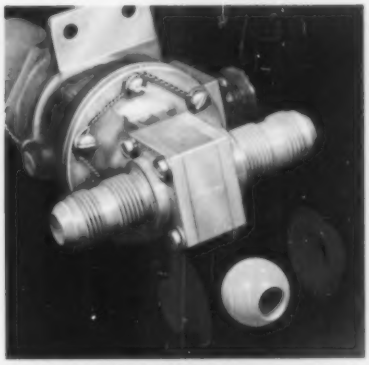
HOSE lined with Du Pont TEFLON is unaffected by the adhesives it handles after three years' use, despite constant flexing. Hose made of TEFLON is now standard equipment for hydraulic, fuel, and other critical lines in jet aircraft and missiles, and is increasingly used to convey corrosives, adhesives, solvents, and superheated steam. (Made by Resistoflex Corporation, Roseland, New Jersey.)



SPIRAL-WOUND GASKETS filled with TEFLON have outstanding corrosion resistance and withstand unusual joint and thermal stresses. Because TEFLON is unaffected by organic solvents and alkalies, longer periods of operation without gasket repair or replacement result. (Manufactured by the Flexitallic Gasket Company, Camden, New Jersey.)

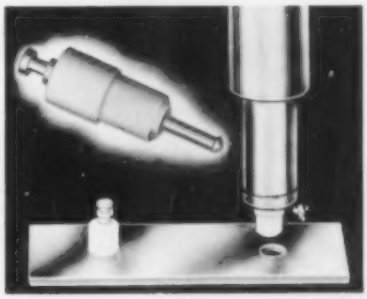


BELLOWS of TEFLON for expansion joints offer flexibility needed to compensate for axial expansion and contraction, and deflection in pipes joining tanks, pumps and reactors. TEFLON absorbs vibration and flexes readily in any direction to safely accommodate pipe movement. (Expansion joint manufactured by United States Gasket Co., Camden, N. J.)



MOLDED BALL SEALS of TEFLON provide tight, long-lasting seals for valves handling hydraulic fluids, water or air. Valve parts of TEFLON have high impact strength, a very low coefficient of friction, no water absorption, and outstanding chemical resistance. (Manufactured by the Sparta Manufacturing Company, Dover, Ohio.)

THIN-WALLED TUBING of TEFLON serves as an insulator around two stainless steel studs in miniature rotary tap switches. Soldering of adjacent connections does not harm insulation of TEFLON, simplifies assembly of switch parts, minimizes accidental grounding. (Manufactured by the Grayhill Company, La Grange, Illinois; tubing supplied by The Polymer Corporation of Pennsylvania, Reading, Pennsylvania, under the trademark *Polypenco*.)



MINIATURE TERMINALS of Du Pont TEFLON tetrafluoroethylene resin are of one-piece construction. The resiliency of TEFLON enables these terminals to be press fit, forming permanent installations having high dielectric strength and heat resistance. ("Press-Fit" terminals manufactured by the Sealectro Corporation, Mamaroneck, New York.)

OVER

DU PONT
REG. U.S. PAT. OFF.
Better Things for Better Living
. . . through Chemistry

PRODUCT ENGINEERING NEWS
PROPERTY AND APPLICATION DATA
ON "TEFLON" TETRAFLUOROETHYLENE RESIN
NO. 2, 1957

Chemically inert Du Pont TEFLON® requires no lubrication—solves problem in new plug valve

BEARING buttons of TEFLON tetrafluoroethylene resin make this unplasticized pvc plug valve, used in piping corrosive fluids, permanently "self-lubricating". A seal of TEFLON is used on the valve shaft to prevent external leakage. The exceptionally low coefficient of friction of TEFLON ($f = .04$) assures ease of turning and prevents seizing and galling.

The buttons are designed as inserts in the valve spindle. In the closed position, the buttons provide a chemically inert block across the open diameter of the pipe. This valve has been operating for more than a year in concentrated HCl at room temperature. The user reports that no problems of sticking or lubrication have occurred at any time so far.

Vital components of Du Pont TEFLON are utilized in this polyvinylchloride plug valve manufactured by Tube Turns Plastics, Inc., Louisville, Kentucky. Exploded view of the valve is based on a transparent mock-up made from Du Pont LUCITE® acrylic resin.

TEFLON resists all chemicals normally encountered in industry. Exceptions to this include attack by the alkali metals under certain conditions. At elevated temperatures and pressures, halogens and certain halogenated chemicals and solvents may affect TEFLON.

Du Pont TEFLON remains tough over a wide temperature range. It has no water absorption. Sticky or viscous materials do not adhere to its waxy surface. It is specified for electrical uses because of a high dielectric strength and extremely low power factor. The combination of these properties gives TEFLON unique design possibilities in a broad range of applications.

It may pay you to investigate Du Pont TEFLON for use in your own application. For data on this outstanding engineering material, available to you without cost or obligation, clip and mail the coupon at left.

E. I. DU PONT DE NEMOURS & CO. (Inc.) POLYCHEMICALS DEPARTMENT
Du Pont Building, Wilmington 98, Delaware. Room 9960
In Canada: Du Pont Company of Canada, Ltd., P. O. Box 660, Montreal, Quebec.

Please send me more information on Du Pont TEFLON tetrafluoroethylene resin. I am interested in evaluating this material for:

NAME_____ POSITION_____
COMPANY_____
STREET_____
CITY_____ STATE_____
TYPE OF BUSINESS_____

TEFLON is a registered trademark...

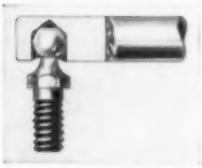
TEFLON is the registered trademark for Du Pont tetrafluoroethylene resin, and should not be used as an adjective to describe any other product or any component part; nor may this registered trademark be used in whole, or in part, as a trade name for any product.

IMPROVED BALL JOINT DESIGNS

The five Tourek-designed Ball Joints illustrated below were developed for special applications and large volume production. Continued research by our engineers assures constantly improved Ball Joint designs. The superiority of TOUREK "STANDARD" Ball Joints results from the accumulated experience of more than 37 years of development and manufacturing.

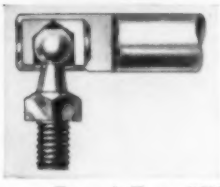
TOUREK OVERTRAVEL BALL JOINTS

Tourek Overtravel Ball Joints are designed to suit your application. This is not a stocked item due to such variations as spring travel, overall length, and spring tension. The tapped hole may vary to allow adjustment. If you have an application that requires an Overtravel, our Engineering department will welcome the opportunity of working with you.



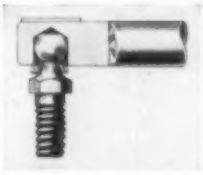
TOUREK TYPE "F" BALL JOINTS

Simplicity of Tourek Type "F" offers a very low cost Ball Joint which can be adapted to various rod or shell sizes. Recommended where side motion will not exceed 15 degrees in either direction. This assembly is supplied with hardened ball screw; shell wear surface may be hardened if so desired.



TOUREK TYPE "K" BALL JOINTS

Tourek Type "K" Ball Joints offer hardened wear surfaces, yet can be adapted to various rod or shell sizes. A very functional design at a minimum cost. Recommended for applications where side motion is restricted.



SNAP-ON BALL JOINT . . CLIP TYPE

Tourek "Snap-on" Ball Joints—Clip Type used in the automotive field for years, permit removal of ball screw for quick length adjustment; also for engagement of shell or rod on pre-assembled ball screw. This unit can be adapted to various rod lengths and shells; ball screw is supplied hardened with soft or hardened shell.

SNAP-ON BALL JOINT . . SLEEVE TYPE

A precision-made Ball Joint designed for a free assembly in those "hard-to-get-at places" or where adjustment of rod length must be made. A slight retraction of the outer shell exposes the socket for quick insertion or withdrawal of the ball. Releasing the spring loaded shell returns it to normal operating position.

No pressure is placed on the ball surface thereby permitting a free movement with maximum .004" end play. A minimum 15° movement in any direction obtained in standard design—for special application side motion may be restricted.

Snap-on Ball Joints—Sleeve Type—can be supplied to accommodate thread range from #10 to ¾". Ball and socket wear surface can be supplied hardened.

Tourek
BALL JOINTS
The Recognized "STANDARD"

MAIL THE COUPON TODAY!

World's largest manufacturer of "STANDARD" Ball Joints. Also makers of Pipe Plugs and quality Screw Machine Products. Range: up to 2⅝" diameter single and multiple spindle machines. Operations include: Threading • Tapping • Milling • Drilling • Grinding • Polishing • Plating • Heat Treating • Silver Soldering.

ESTAB. 1920

J. J. TOUREK MANUFACTURING COMPANY
1901 SOUTH KILBOURN AVENUE, CHICAGO 23, ILLINOIS

Gentlemen:

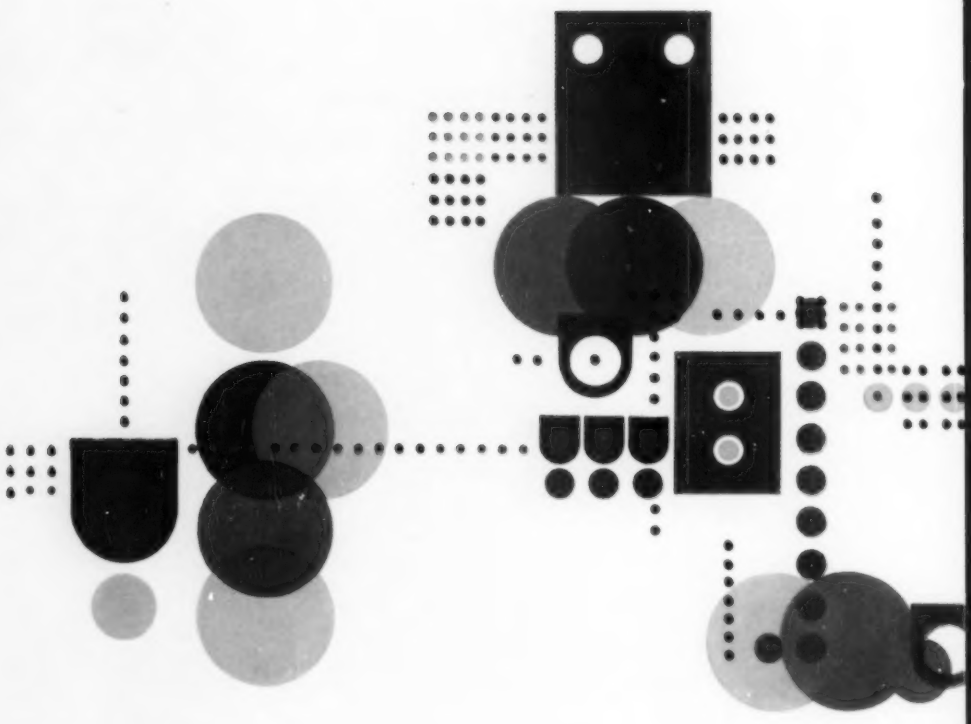
Please mail to me at once, complete information and prices on TOUREK "STANDARD" Ball Joints.

Name_____

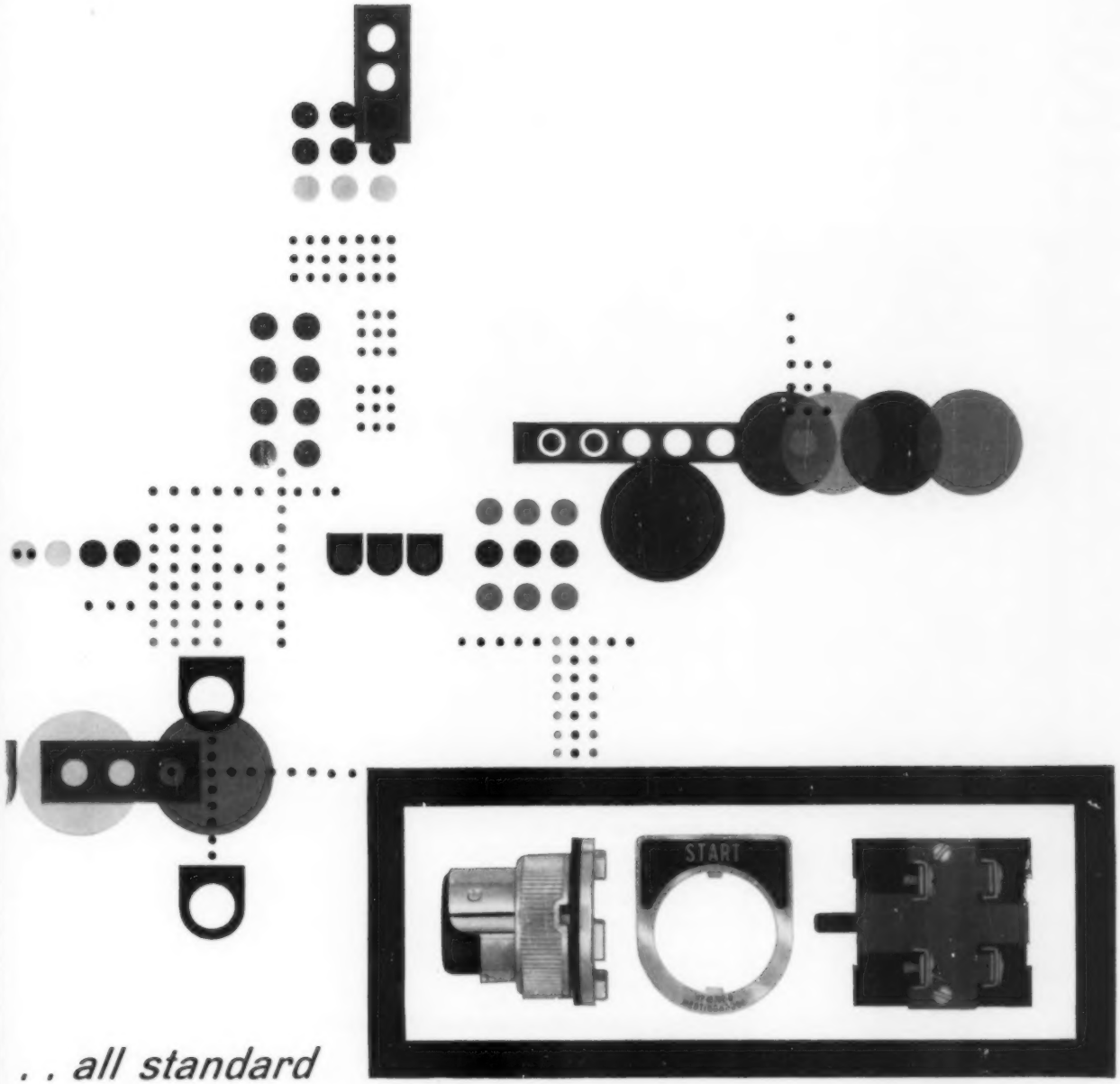
Company_____

Address_____

City_____ Zone____ State_____



Pushbutton control arrangements almost to infinity . . .



. . all standard

How'd you like a stock of 1,500,000 pushbutton controls on hand at all times for original equipment needs or for production purposes?

Sound prohibitive space-wise, or too expensive? Not at all. Just 38 Westinghouse components (shown above) do it because all parts are standardized and interchangeable. And always available from stock.

If you need controls for any application, write for the free 72-page *Pushbutton Guide*, B-6749. For control where moisture is a problem, write for free Booklet, B-7022, about Oil-Tite* controls. Write to Westinghouse Electric Corporation, Box 868, Pittsburgh 30, Pa. Or call your Westinghouse Distributor.

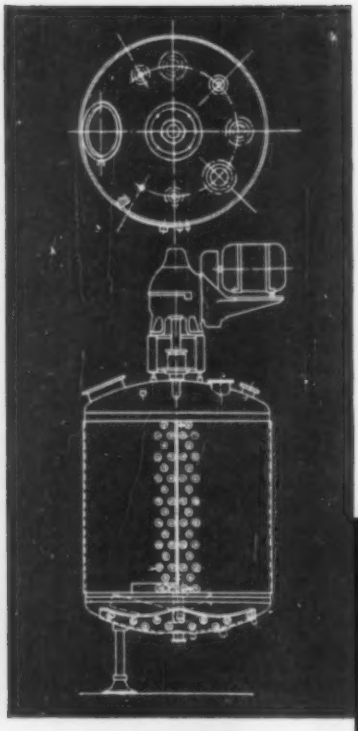
*T. M.

J-30248

YOU CAN BE SURE... IF IT'S

Westinghouse

can you afford not to use TITANIUM?



By themselves, catalog prices of raw materials can be misleading. For it's the final cost—in terms of service life—that really determines what you pay for equipment.

The following table, based on cost analysis by the Pfaudler Company, indicates their estimate of comparative costs of producing the reactor unit shown at the left, using titanium, and two other well-known, corrosion-resistant metals.

	REM-CRU A-55 TITANIUM	METAL A	METAL B
Cost per lb.	$14.60	$0.8025	$2.62
But titanium's light-weight means less is needed . . .			
Material Required	250 lbs.	785 lbs.	675 lbs.
So the comparative cost factor is reduced . . .			
Material Costs	$3650.00	$630.00	$1768.00
Fabrication takes the lions' share, so . . .			
Cost of Finished Reactor	$12,150.00	$2391.00	$4670.00
And in corrosive chlorides, hot acids, and many other environments, laboratory and service data show . . .			
Service Life	5 years	6 months	1 year
NOW . . . COST Per Service Year	**$2430.00**	**$4782.00**	**$4670.00**

Reactor unit of REM-CRU titanium built by the Pfaudler Co., Rochester, N. Y. and Elyria, Ohio a skilled fabricator of titanium and other corrosion-resisting materials.

Don't be fooled by raw material costs alone—*it's the cost per service year that really counts.* Then, too, down-time losses while equipment is being replaced can quickly mount up. Another plus for longer-lasting titanium. Why not let a REM-CRU engineer help you make the best, most profitable use of titanium?

REM-CRU TITANIUM

To keep abreast of the latest developments on this vital metal, write to Dept. P-1 for the Rem-Cru Review—a free periodical presenting the latest technical data on titanium alloys.

REM-CRU TITANIUM, INC., MIDLAND, PENNSYLVANIA

Sales Offices: 3338 South Malt Avenue, Los Angeles 22, California • 4501 W. Cortland Street, Chicago 39, Illinois • 405 Lexington Avenue, New York 17, N. Y.

DOW CORNING CORPORATION

Silicone News

FOR DESIGN ENGINEERS No. 34

Silastic Eliminates Slippage On Oscillograph Feed Rolls

The ability of Silastic*, Dow Corning's silicone rubber, to retain uniform resiliency from —130 to 500 F aids our development of natural resources by increasing the reliability of oil-finding instruments.

Seismic impulses created by detonating explosive charges underground are picked up by seismometers, amplified, and recorded by oscillographs on moving rolls of photographic paper. To obtain truly accurate readings, it is essential that the paper, fed by rubber surfaced drive rollers, move at a constant rate of speed.

Feed rolls coated with organic rubber hampered the accuracy of readings because the rubber hardens when exposed to low temperatures. The resultant changes in friction between rolls and paper caused varying degrees of slippage.

Atlantic Refining Company of Dallas, Texas, solved the problem by surfacing the feed rolls with Silastic, the silicone rubber that shows little or no change in hardness over a wide temperature span. Silastic was first molded (Cont. Pg. 2)

SILICONES LUBRICATE RUBBER AND PLASTIC COMPONENTS IN KELVINATOR REFRIGERATOR

The problems generally associated with lubricating moving rubber or plastic parts in contact with metal are easily solved today with silicone fluids and greases. Good examples are found in these applications for Dow Corning 200 Fluid as a lubricant for plastics in the new Kelvinator "Foodarama."

Combining permanent resistance to oxidation and moisture with a flat temperature-viscosity curve, 200 Fluid provides excellent, long term lubrication for—

(A) acrylonitrile-styrene copolymer hinge pins on the "Breakfast Bar" doors;

(B) nylon roller bearings mounted on steel pin shafts that support the roll-out shelves;

(C) polystyrene tracks that provide a sliding surface for the porcelain-enameled crispers;

(D) contact point between vinyl door gasket and polystyrene trim on the cabinet;

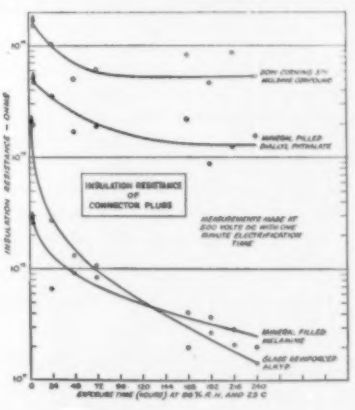
(E) nylon roller bearings that support the steel roll-out basket and the nylon spacers that slide on the steel side rails of the basket.

Applied as a 20-1 dilution in toluene or wiped on full strength, the 200 Silicone Fluid used on the Foodarama is extremely economical. The coating on (Cont. Pg. 2)

Silicone Molding Compound Has Better Insulation Resistance Than Plastics

While Dow Corning 301 Molding Compound is frequently specified for electrical parts because of its outstanding resistance to high temperatures, this versatile material also has electrical properties superior to comparable plastics at room temperature. Take insulation resistance, for example—

The accompanying graph traces a summary of tests run on four miniature 26-contact connectors molded by Continental Connector Corporation, Long Island City, N. Y. All plugs were identical in physical


INSULATION RESISTANCE OF CONNECTOR PLUGS
MEASUREMENTS MADE AT 500 VOLTS DC WITH ONE MINUTE ELECTRIFICATION TIME
MINERAL FILLED DIALLYL PHTHALATE
MINERAL FILLED MELAMINE
GLASS REINFORCED ALKYD
INSULATION RESISTANCE — OHMS
EXPOSURE TIME (HOURS) AT 95% R.H. AND 25°C

*T.M. REG. U.S. PAT. OFF. (Cont. Pg. 2)

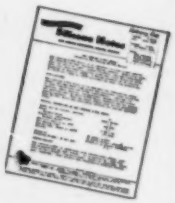
FOR DATA RELATING TO THESE ARTICLES, CIRCLE REFERENCE NUMBER IN COUPON ON NEXT PAGE

MORE

Silicone News

DOW CORNING CORPORATION

DOW CORNING PUBLICATIONS ON NEW DEVELOPMENTS AND TECHNICAL DATA . . . .



Dow Corning Silicone Compounds, for dielectric applications, for release of plastic and rubber moldings, and for protecting finely machined thread parts, are described and compared in a handy reference pamphlet. *No. 344*

Dow Corning 2106 Resin. A recently revised data sheet on this high-strength, silicone laminating resin contains added information and comprehensive tables and graphs on physical and electrical properties. *No. 345*

Looking for a near-at-hand source of supply for parts or products made with Dow Corning Silicones? We'll be glad to send you any of the following:

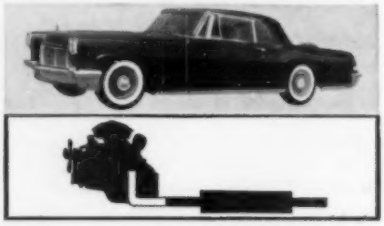
Paint Formulators or Manufacturers ... *No. 346*
Masonry Water Repellent Formulators .. *No. 347*
Laminators of silicone-glass parts ..... *No. 348*
Manufacturers of Class H Motors ..... *No. 349*
Manufacturers of Class H Transformers . *No. 350*
Manufacturers of Class H Insulating Materials ..... *No. 351*
Distributors of Class H components; silicone greases and compounds ..... *No. 352*
Fabricators of silicone rubber parts, wire and cable ..... *No. 353*
Producers of pressure sensitive tape .... *No. 354*

All New — 1957 Guide to Dow Corning Silicones is a twelve page, fact-filled catalog which briefly describes the silicone products of interest to most industries. Containing latest data and information, the guide is designed expressly to help you enjoy the advantages, profits, and savings made possible through imaginative use of these unique engineering materials. *No. 355*

Antifoam B, a new silicone defoamer, has greater stability than any other water dilutable silicone foam-killer commercially available. Will not separate, oil out, plate out, settle or precipitate in most applications. Retains uniformity and effectiveness even if frozen or boiled. Ready to use, it eliminates need for diluting or pre-mixing. *No. 356*

MANIFOLD ON LINCOLN "CONTINENTAL" PROTECTED WITH SILICONE BASED PAINT

Growing numbers of designers are solving the problems of keeping a finish on hot metal surfaces by specifying finishes formulated with Dow Corning Silicones. There could hardly be a more impressive example of the serviceability realized with silicone based paint than the exhaust manifold application on Ford's Continental Mark II.



Ford's selection of a silicone based finish goes back to the 1952 Lincoln, the *first* automobile to feature exhaust manifolds and crossover connections finished with a silicone based service-type paint. This original automotive use of a silicone based finish was highly successful; the coating was as black and glossy as when new after 100,000 miles at temperatures up to 500 F and exposure to road salt, slush, and water.

The current Continental application, however, is even more severe. Applied to a flexible metal bellows that connects manifold and exhaust, a "Sicon" finish made with Dow Corning silicone resins by Midland Industrial Finishes, Waukegan, Ill., is exposed to constant flexing and temperatures in the 500 F range. Nevertheless, the heat stable finish resists chipping and flaking. In addition to providing the most practical protection for metals that get hot in service, silicone based finishes offer excellent resistance to moisture, oxidation, chalking, fading and chemical attack. *No. 342*

SILICONES LUBRICATE REFRIGERATOR *(Cont.)* the crisper covers, for example, costs a mere $0.0063 per cover!

Performance and economy like this typify Dow Corning silicone fluids and greases. They not only retain efficient lubricity at temperatures far above and below the limits of the best organic lubricants obtainable, but they actually tend to lengthen the life of rubber and plastic components. For many applications involving heat, cold, rubber and plastics, silicone lubricants offer the closest thing to "permanent lubrication" yet developed. *No. 340*

SILASTIC ELIMINATES SLIPPAGE *(Continued)* and cured on feed rolls for this purpose in 1950 by Immel Engineering & Development Company, Dallas. Silastic coated rolls have been standard equipment on all Atlantic oscillographs ever since; no replacements have been necessary to date; errors due to paper slippage have been practically eliminated and are now completely disregarded. *No. 341*

SILICONE COMPOUND vs PLASTICS *(Continued)* form, but each was molded from a different material as indicated on the graph.

Not only did the plugs made of 301 Molding Compound have the highest initial insulation resistance, but their margin of superiority broadened substantially after 240 hours at 96% RH. These tests were conducted at room temperature; at elevated temperatures the superiority of the silicone molding compound is even more pronounced.

Performance like this is one of the reasons why Continental, among the world's largest producers of connectors, reports increasing interest in "301" molded units. Already undergoing tests in guided missiles, industrial ovens and even kitchen ranges, 301 Molding Compound is manufactured to meet Specification MIL-M-14E, Grade MSI-30. Continental has announced that its entire connector line will soon be available in 301 Molding Compound. *No. 343*

Dow Corning Corporation, Dept. 8613, Midland, Michigan

Please send me: 340 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356

NAME _____

TITLE _____

COMPANY _____

STREET _____

CITY _____ ZONE ____ STATE _____

SILICONE NEWS is published for product design and development engineers by

DOW CORNING CORPORATION
MIDLAND MICHIGAN

first in silicones
DOW CORNING SILICONES

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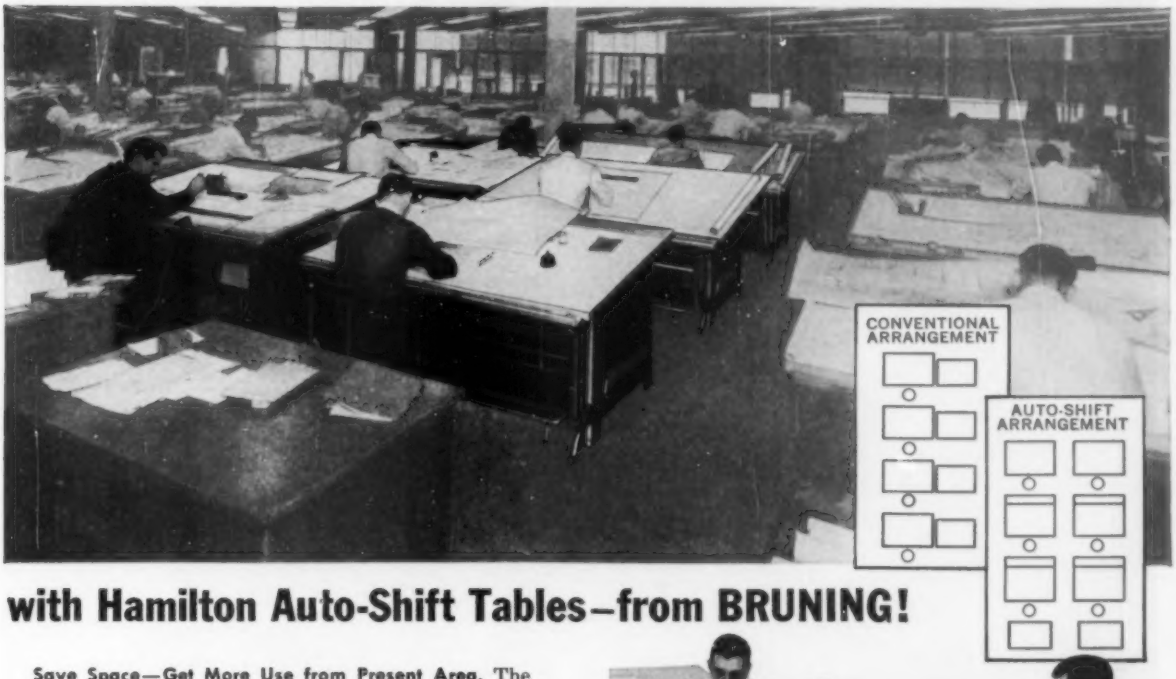
Put Six Draftsmen in the Space Now Occupied by Four

YET GIVE EACH MAN MORE EFFICIENT, COMFORTABLE WORKING ROOM...



with Hamilton Auto-Shift Tables—from BRUNING!

Save Space—Get More Use from Present Area. The same floor space (about 250 square feet) taken up by *four* boards with separate reference desks will easily accommodate *six* Auto-Shifts. Auto-Shift combines a board and reference desk in one compact unit. The draftsman uses the board of one table for drawing, uses the large surface and drawers of the table behind him for reference.

Eliminate Waste Motion—Save Man Hours. Auto-Shift eliminates needless detours for reference material and supplies. The draftsman merely turns on his stool for quick, easy access to the reference surface or drawers of the Auto-Shift table behind him.

Reduce Draftsman Fatigue—Boost Productivity. Auto-Shift provides fast, easy board adjustment—lets the draftsman change working position often for greater comfort and efficiency. Foot release frees top for fast, convenient height adjustment. Hand release permits quick, easy slope adjustment—slight fingertip pressure sets counterbalanced top at any desired angle. Seated or standing, draftsman can reach any part of the board without strain.

Mail coupon today for detailed information on the important savings offered you by Auto-Shift.

Only Auto-Shift Offers You These 3 Big Advantages!

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Ask your Bruning representative for information about the Bruning-Hamilton free analysis and planning service for improving your drafting operation—or use coupon below. No obligation.

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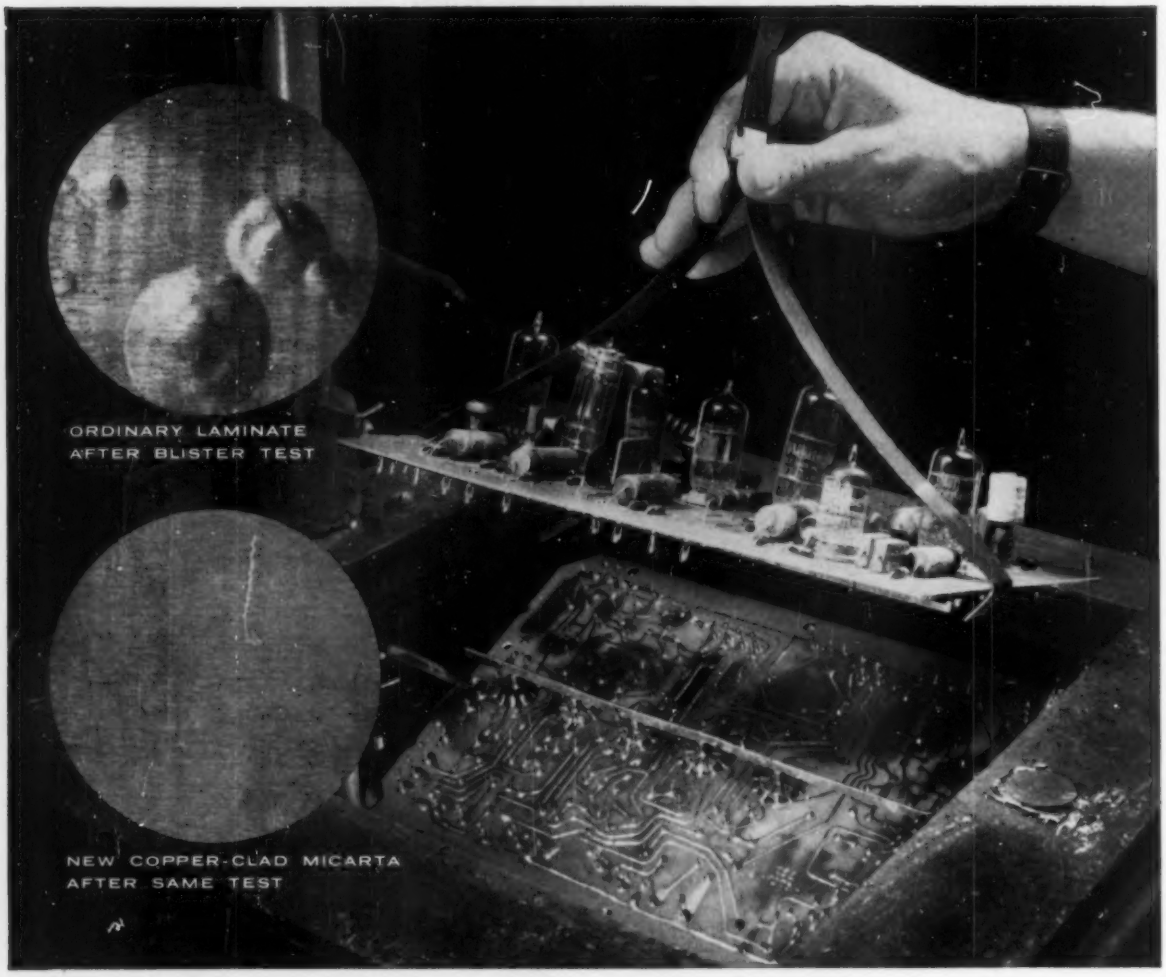


New copper-clad **MICARTA®** takes dip solder bath without blistering!

New H-3032 copper-clad MICARTA® cuts costs and production time of printed circuits. Copper-clad MICARTA speeds up soldering, without the normal accompaniment of an increase in rejects and missed connections. It can be cold punched without cracking or chipping.

The laminate won't blister even when dip soldered for 10 seconds at 500°F! Examine the two close-up photographs. One shows an ordinary laminate after a laboratory test. Note the blistering, then look at the MICARTA dip soldered for the same length of time—and there is no blistering!

A special adhesive is used which has the same high electrical properties, solvent resistance and low moisture absorption as the MICARTA laminate itself. Actually, adhesive strength is increased during soldering.

Because of a new adhesive process, copper-clad MICARTA keeps its high bond strength—from 10 to 13 pounds versus an industry standard of six pounds—even after heating and cooling is repeated many times. This is especially valuable for electronic circuits.

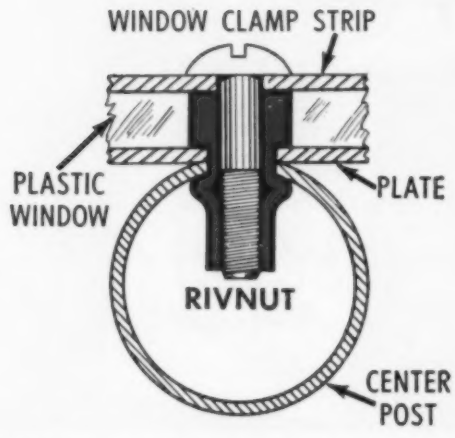
Copper-clad MICARTA may be the answer to your circuit assembly problem. Write for further information and technical data to Westinghouse Electric Corp., MICARTA Div., Hampton, S. C.,

J-06624-X

YOU CAN BE SURE...IF IT'S Westinghouse

B.F.Goodrich Rivnut

provides blind nutplate so solid it's a shockproof seal

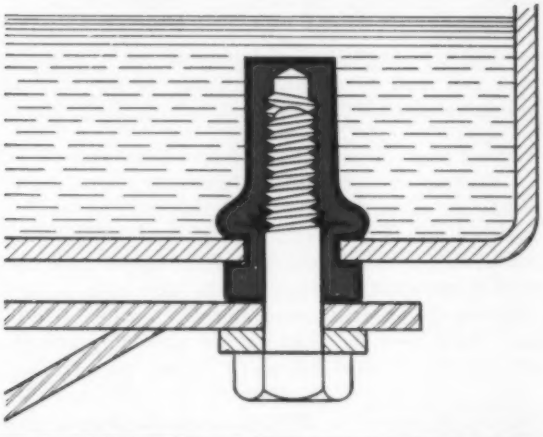


Here's a tough fastening problem that puzzled designers of airplane windows. They needed a nutplate and a blind rivet solid enough to serve as a shockproof seal. One B. F. Goodrich Rivnut solved the problem by performing all three jobs in one operation.

In seconds, one man upsets the Rivnut, securely rivets the plate to center post. The firm bulge in the Rivnut shank conforms to the curvature of the tube, giving a shockproof seal that keeps weather out. Rivnut head serves as spacer for plastic window, and provides 6 clean, firm threads that hold clamp strip and window securely in place.

Best of all, Rivnuts cut costs by reducing assembly time. Here's a typical example:

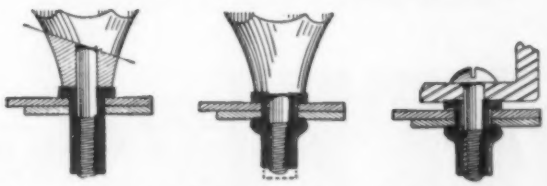
RIVNUT cuts fastening time 90% by eliminating brazing and tapping



A manufacturer of industrial oilers was brazing nutplates on his reservoir tanks for bolting to brackets. This required three separate operations—brazing, tapping, and thread cleaning. Too often, brazing caused warping and leaks. In addition, he had to fuss with bolts and washers to maintain proper shim space.

By switching to Rivnuts, he reduced all three steps to one quick operation. Rivnuts cut assembly time 90%, assured uniform quality in every product. Rivnuts can work wonders for you, too. Call on us for engineering help, or:

HOW RIVNUTS PROVIDE AT LEAST 6 CLEAN THREADS IN ONE SIMPLE OPERATION:



1 Rivnut is threaded onto pull-up stud of heading tool, then inserted.

2 Tool lever operates pull-up stud forming a bulge in the Rivnut shank.

3 After upset, Rivnut threads are still clean and intact, ready for screw attachment.

SEND NOW FOR FREE RIVNUT DEMONSTRATOR

Demonstrates with motion how Rivnuts fasten *to* and *with*. Explains construction, gives proved applications. Write to *B. F. Goodrich Rivnuts, Dept. PE-17, Akron, Ohio.*

B.F.Goodrich

AVIATION PRODUCTS

a division of The B. F. Goodrich Company, Akron, Ohio

Are You Aware of the Exciting Opportunities for Product Improvement that Exist Now?

Today, industry is forging ahead in the development of products little dreamed of only a few short years ago.

Instrumentation . . . miniaturization . . . more automatic production . . . all are demanding parts and components with new operating advantages. And High Nickel Alloys are playing an important part in meeting the needs. Are *you* aware of the opportunities High Nickel Alloys offer? For example, do you know you can . . .

. . . Design smaller, lighter weight units through the use of "extremely sensitive" alloys that respond to very weak electrical currents?

. . . Assure precision product performance with the help of an alloy that exhibits infinitesimal size change through temperature ranges up to 400°F?

. . . Compensate a given magnetic field for temperature changes to insure consistently accurate product performance?

And the list goes on . . . an exciting list of properties that can lead to rewarding fields of new and improved products!

Getting High Nickel Alloys to do special jobs for you . . . making them behave in the way *you want them to behave* . . . is an opportunity we welcome. By making a team of your engineering experience and Carpenter's ability to produce closely controlled High Nickel Alloys with predetermined behavior, you often take an immediate step to product improvement. To help you in this job, Carpenter manufactures an unusually complete line of High Nickel Alloys . . . Temperature Compensator, Low Expansion, High Permeability and Glass Sealing Alloys. These are available in the largest variety of forms including strip, wire, bars, tubing, forging billets, etc. Ask for detailed engineering and application information. A note on your company letterhead is all that's necessary.

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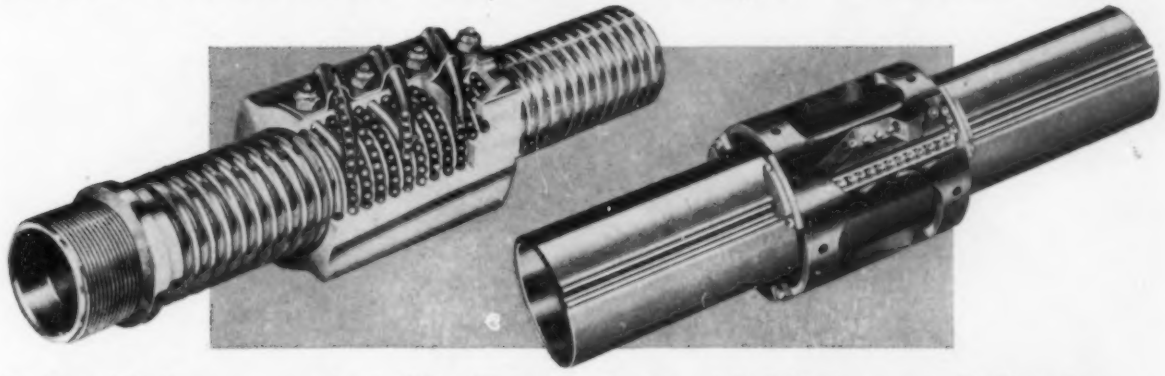
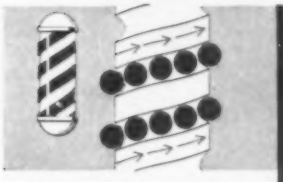
These MODERN Recirculating Ball Units can help you...

SOLVE ACTUATION and TORQUE PROBLEMS

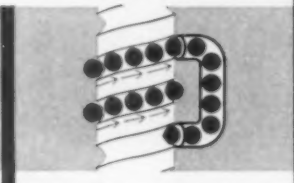


Saginaw b/b Screws guaranteed 90% efficient —offer 6 major advantages for designers

Available in custom machined and commercial rolled thread types—have been built from 1½ inches to 39½ feet long—⅜ to 10 inches diameter.



Nut *glides* on steel balls. Like stripes on a barber pole, the balls travel toward end of nut through spiral "tunnel" formed by concave threads in both screw and mating nut.



At end of trip, one or more tubular guides load balls diagonally back across outside of nut to starting point, forming closed circuit through which balls recirculate.

1 VITAL POWER SAVINGS. With guaranteed efficiency of 90%, Saginaw b/b Screws are up to 5 times as efficient as Acme screws, require only ⅓ as much torque. This permits much smaller motors with far less drain on the electrical system. Circuitry is greatly simplified.

2 SPACE/WEIGHT REDUCTION. Saginaw b/b Screws permit use of smaller motors and gear boxes; eliminate pumps, accumulators and piping required by hydraulics. In addition, Saginaw b/b Screws themselves are smaller and lighter. Units have been engineered from 1½ in. to 39½ ft. in length.

3 PRECISE POSITIONING. Machine-ground Saginaw b/b Screws offer a great advantage over hydraulics or pneumatics because a component can be positioned at a predetermined point with precision. Tolerances on position are held within .0006 in./ft. of travel.

4 TEMPERATURE TOLERANCE. Normal operating range is from −75° to +275° F., but assemblies have been designed in selected materials which function efficiently as high as +900° F. These units are practical where hydraulic fluids have lost efficiency or reached their flash point.

5 LUBRICATION LATITUDE. Even if lubrication fails or cannot originally be provided because of extreme temperatures or other problems, Saginaw b/b Screws will still operate with remarkable efficiency. Saginaw units have been designed, built and qualified for operation without any lubrication.

6 FAIL-SAFE PERFORMANCE. Far less vulnerable than hydraulics. In addition, Saginaw offers three significant advantages over other makes: (1) Gothic arch grooves eliminate dirt sensitivity, increase ball life; (2) yoke deflectors and (3) multiple circuits provide added assurance against operating failure.

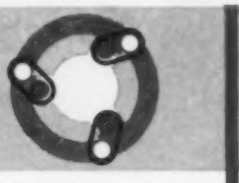
Saginaw ball bearing Screws and Splines

SAGINAW STEERING GEAR DIVISION OF GENERAL MOTORS

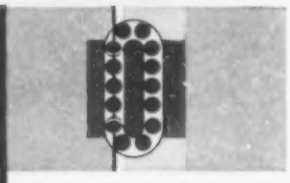
WORLD'S LARGEST PRODUCER OF BALL BEARING SCREWS AND SPLINES

Saginaw b/b Splines average 40 times lower friction coefficient than sliding splines

Transmit or restrain high torque loads far more efficiently—have been built from 3 inches to 10 feet long—⅜ inch to 6 inches in diameter.



The *Saginaw b/b Spline* radically increases the efficiency of transmitting or restraining high torque loads. Instead of *sliding* against each other, surfaces *glide* on rolling balls.



The steel balls recirculate in closed circuits formed by mating longitudinal raceways spaced around the circumference of inner and outer splines. Guides return balls.

This revolutionary new kind of spline utilizes the same basic principle pioneered by Saginaw in the ball/bearing screw.

It permits new engineering designs never before practical—literally lets you achieve the "impossible"! In any application where column length must change under torque load, the Saginaw b/b Spline offers greatly decreased friction, less wear, longer life, more dependable operation. It can be fitted with integral gears, clutch dogs, bearing and sprocket seats or a wide choice of other attachments for use with electric, hydraulic or pneumatic units. To convert push-pull to rotary motion, helical types are available with very high leads, ranging from 20:1 to 100:1.

SEND TODAY FOR THIS FREE 1957 ENGINEERING DATA BOOK...

Saginaw Steering Gear Division
General Motors Corporation
b/b Screw and Spline Operation
Dept. 4J, Saginaw, Michigan

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Exon engineers have combined properties so precisely in Exon 480 that they have created the specific resin for phonograph records.

A "biscuit" compounded of Exon 480 assures the finished recording of unusually high tonal quality, as well as breakage resistance.

For production economies, the higher bulking density of Exon 480 speeds banbury output as much as 25%. Other assets: excellent moldability, good heat and light stability, compatibility with vinyl plasticizers, stabilizers and pigments.

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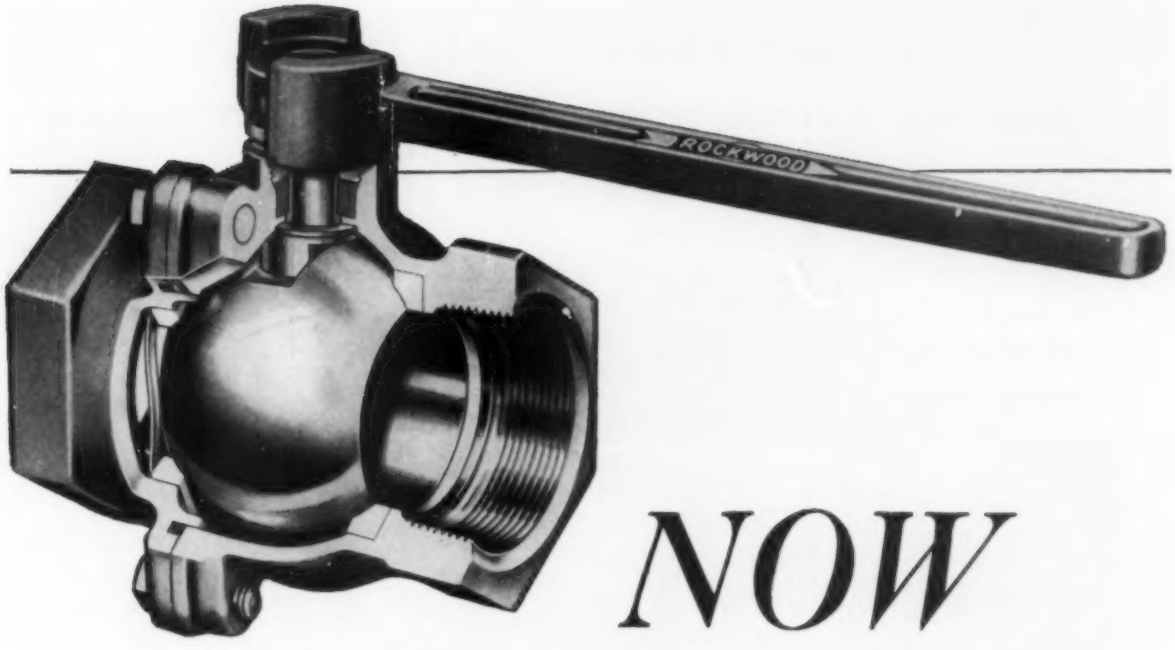

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The new Rockwood Bronze Ball Valve for use with steam offers you many unusual benefits.

It Handles up to 125 Pounds of Steam per square inch and 350°F, with ease.

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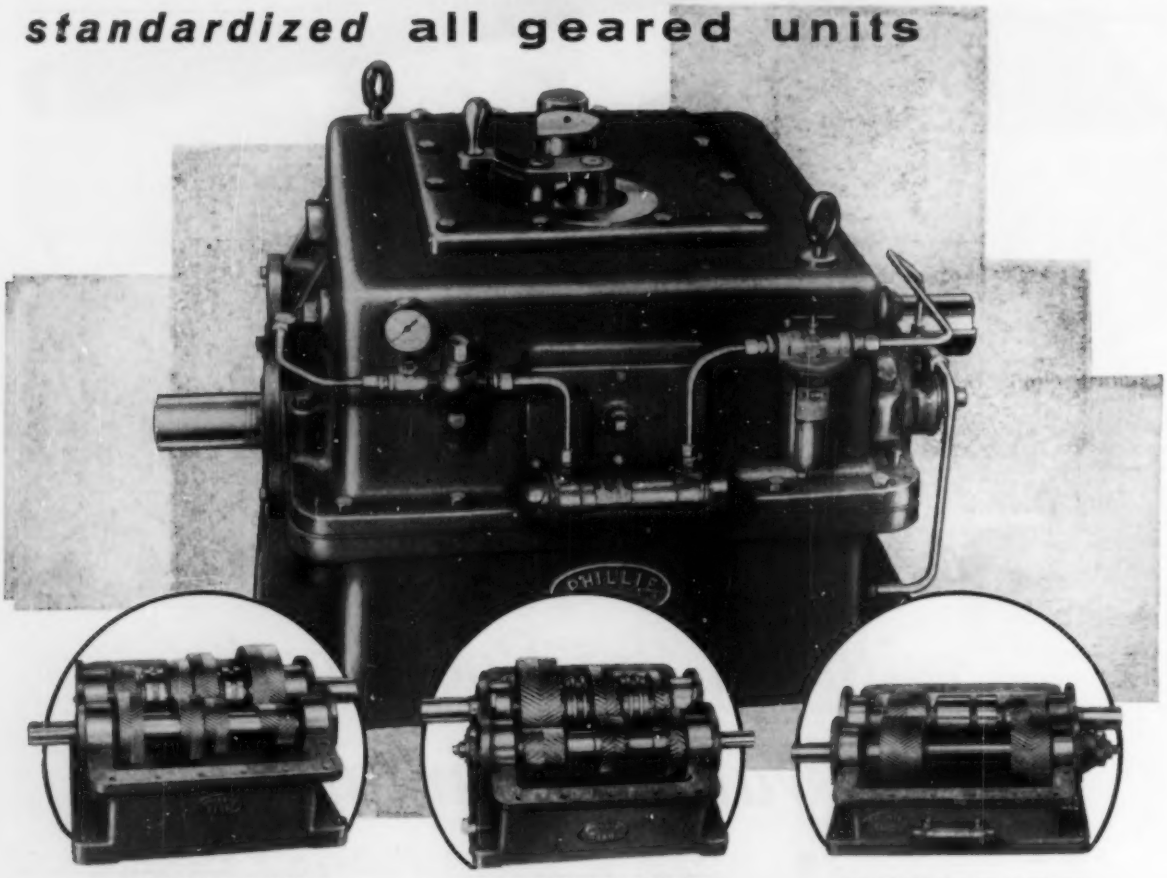

4 SPEED UNIT **3 SPEED UNIT** **2 SPEED UNIT**

These self-contained, compact, all-geared change speed Units are available in 2, 3 and 4 speed changes, providing definite ratios of speed reducing, speed increasing (or a combination of both) to meet virtually any selective speed drive requirement. They are designed to fill industry's need for an efficient, precision-built standardized line . . . eliminating the high costs and delayed deliveries usually associated with specially designed units. They are ideal for use on wire drawing machines, large machine tools, mixing equipment, sludge pumps, extruding machines, dry cleaning equipment, etc. Gears and pinions are Continuous Tooth Herringbone type. Shafts, bearings, clutches and housings are of the finest quality to assure the user of long, trouble-free service . . . Ratings are according to AGMA Standards, with allowance for 100% overload in starting and for momentary shock loads. These units are designed to permit the heavy overhung loads resulting from the use of sprockets or pulleys.

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BRASS keeps sales up... manufacturing costs down

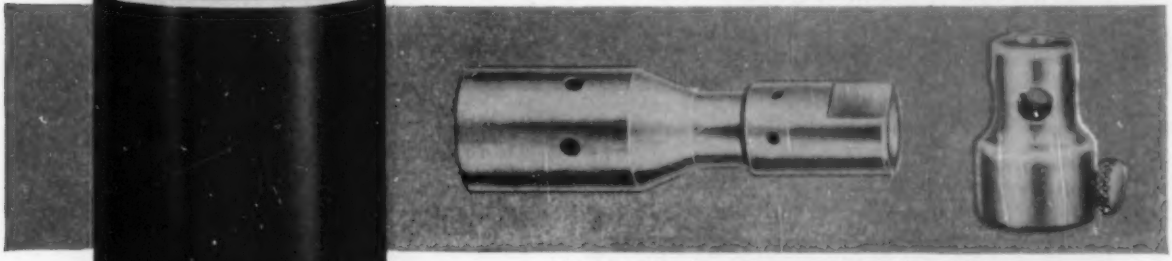
TURNER IS A LONG-TIME USER OF ANACONDA BRASS ROD AND TUBE— GIVES 10 REASONS WHY—

Blow torches built by The Turner Brass Works, Sycamore, Ill., have a reputation for dependable operation and long life. Since 1871, brass has been used consistently in their construction and has built a quality reputation for Turner. Turner prefers Anaconda Brass as a quality metal and looks to The American Brass Company as a quality source of supply. 5673

These are the reasons given:

1. Brass is the quality material needed for the service.
2. Brass is easily machined at high speed, with less tool breakage – manufacturing costs are 15% lower than with other metals.
3. Close tolerances are easily held with brass.
4. Threading holds well – yet accessories are easily screwed on and off.
5. Brass takes a good finish – polishing is easy and economical.
6. Clean, polished brass products have proven high sales appeal.
7. Brass stands up under alternate heating and cooling.
8. Brass resists corrosion – the torches are used on land and sea, throughout the world.
9. Brass gives superior wear on valve seats.
10. Brass has high public acceptance as a quality material.

Turner liquefied petroleum torch No. LP-555, with disposable fuel tank. Below are accessories of brass—holder for soldering tip and a heavy-duty burner.



The American Brass Company, Waterbury 20, Conn.
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Offset or aligned...

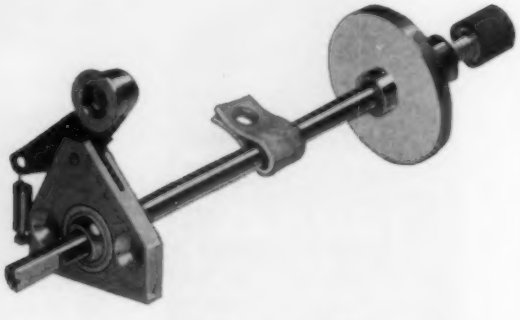
HEIM *Unibal* BEARINGS

operate smoothly

The **Diebold Portable Microfilm Camera** weighs only 20 lbs., is about the size of a portable typewriter, yet it is one of the fastest and lowest cost methods of making a copy—a microfilm copy in a split second, that projects to full size onto a brilliantly illuminated reader screen.

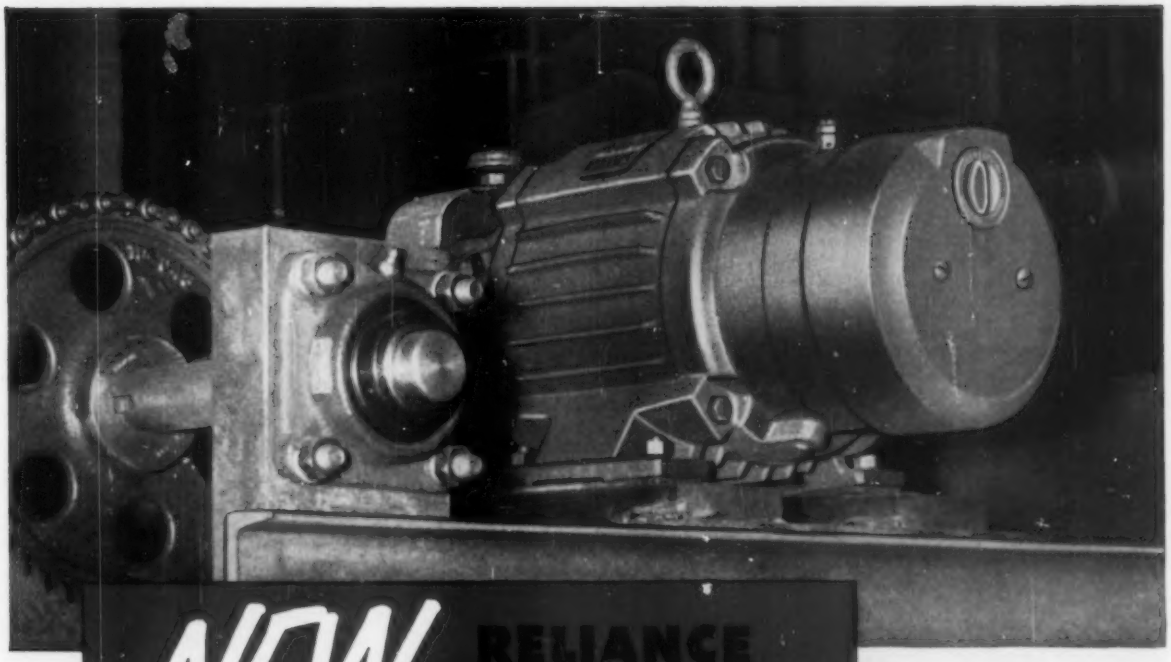
The **Heim Unibal Spherical Bearing** consists of a single ball (through which the shaft passes) revolving in bronze bearing inserts which are housed in the bearing body. This Unibal type of bearing has a large surface supporting area; carries heavier loads where required; and corrects shaft misalignment in all directions.

A wide range of stock sizes is carried by Heim distributors across the U.S.A. and in Canada. Heim Unibal Bearings, Heim Unibal Rod Ends, and the complete line of Pillow Blocks, Flanged Bearings, etc. are listed in Heim catalog No. 100. Be sure you have the latest copy in your engineering department.



The **shaft and bearing assembly** shown is the mechanical heart of the Diebold 9600 Portable Microfilm Camera. The rubber roller on the end of the shaft drives film in a film magazine in synchronism with copy being photographed. Smooth operation of this shaft is imperative since any hesitation or binds will show up on the film as density bars in the picture. The shaft rotates in a horizontal position continuously, and, when copy is being fed into the camera, a cam raises the shaft 5 to 10 degrees out of alignment to contact the film. A loose bearing could be used to permit this misalignment, but might result in irregularities. With the Heim Unibal Bearings, the smooth operation necessary is assured in either the offset or the aligned position of the shaft.

THE HEIM COMPANY / Fairfield, Connecticut



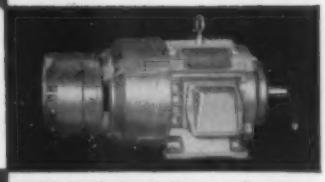
NEW RELIANCE BRAKEMOTOR

These new motors are specifically designed for tough operating conditions. Corrosion-proof cast-iron housings and sealed joints make this motor impregnable to foreign material.

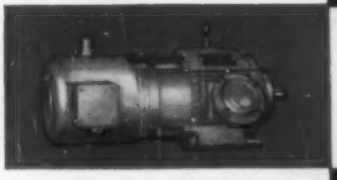
Braking torque ratings from 3 ft. lbs. thru 345 ft. lbs. Fail-safe mechanism immediately applies brake in case of power failure. One piece molded brake linings provide fast, smooth stops and unmatched holding power for heavy loads.

Simple brake has only six parts and requires no control wiring or auxiliary electrical equipment. Compact construction requires a minimum of space. Wearing parts are easily accessible for fast maintenance.

For further information write for bulletin B-2503. B-1633

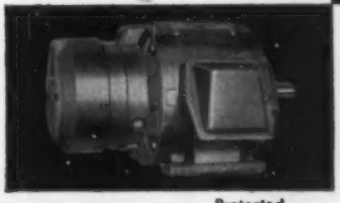


Totally-Enclosed, Corrosion-Proof



Explosion-Proof—Cl. I, Gr. D and Cl. II, Grs. E, F & G

Corrosion-Proof Gearmotor



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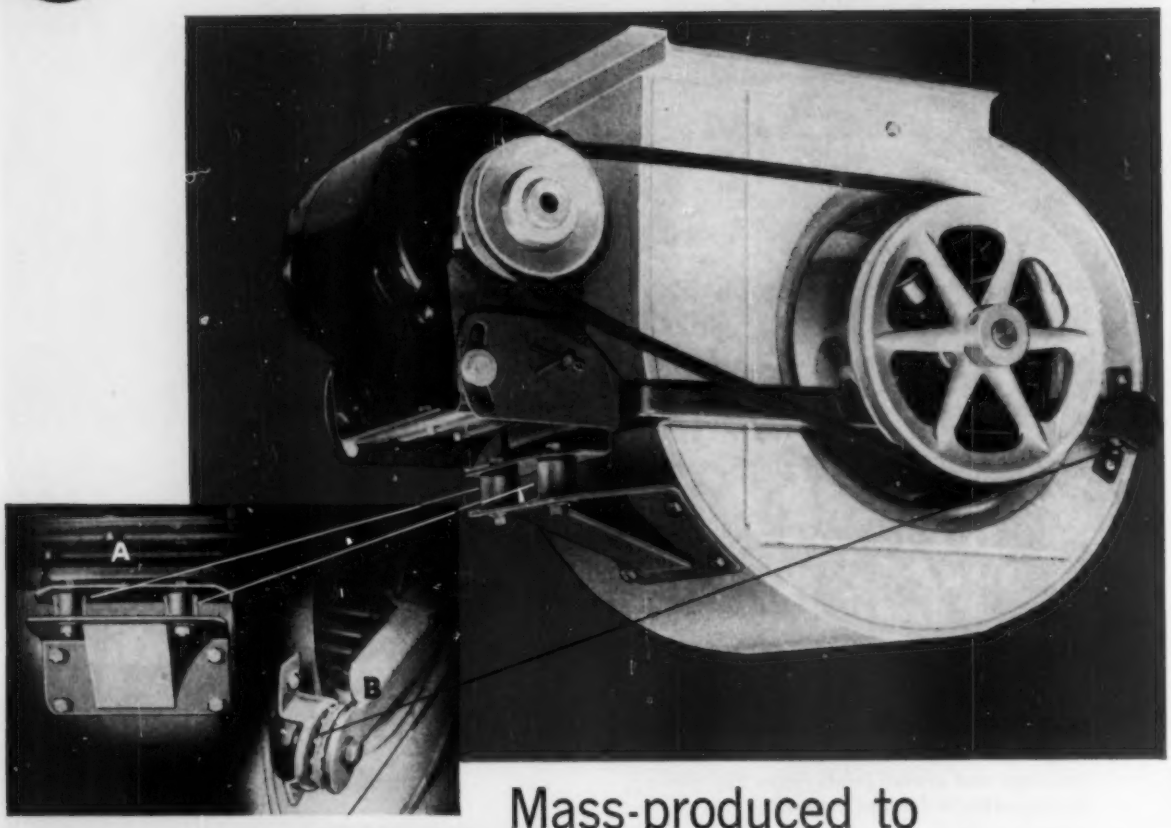
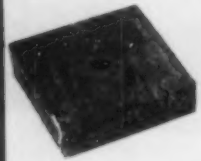
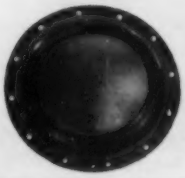


U. S. Molded Shock Mounting for shock absorption when shipping delicate instruments. An electric typewriter manufacturer, for instance, has cut down shipping damage to ½% and cut packaging costs considerably. Improved rubber-to-metal bonding permits their re-use.



U. S. Molded Drop Forge Mounting in service for over 13 years—absorbed *80 million* blows of almost 1600 lbs. force each without wearing out—removed only when steel retaining pins had corroded.

U. S. Molded Diaphragm for controlling liquid flow through motor valves. Offers high burst resistance, retention of molded shape under high pressures, and exact fabric placement.



Mass-produced to exacting specifications

U. S. Rubber Molded Mountings and Connectors help keep blowers operating at "whisper silence".

A well-adjusted system for a forced warm air furnace requires that all vibration and noise be kept to an absolute minimum. In this leading "sulky" type blower, the entire moving parts assembly floats on a cushion of U. S. Molded Rubber Mounts (A) and firm, but movement-free, U. S. Rubber Finger-Flex Connectors (B). In this manner, all mechanical vibrations are isolated—the blower operates in silence.

U. S. Rubber Molded Mountings and Connectors were selected because of their ability to retain "molded in" shape during their entire long life and for the economy they provide.

Yet, this is only one of hundreds of applications wherein U. S. Engineered Rubber Products *do jobs no other material can do.* "U. S." engineers will help you solve any molded rubber problem. Contact us at Rockefeller Center, New York 20, N. Y. In Canada, Dominion Rubber Co., Ltd.

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Thermoswitch® Is Rugged, Adaptable, Heat Controller

ASHLAND, MASS. — Word emanating from here is that Fenwal Incorporated's THERMOSWITCH units are usually the best solution for a design engineer with temperature-control problems.

THERMOSWITCH thermal controls are adaptable, sensitive, responsive, small, tough, and accurate — and their price is right. They frequently replace controllers costing much more, and do a better job.

Their principle of operation is unique — and highly competitive in terms of every quality most design engineers would require. The unique principle is this: *the activating control element is a single-metal shell that expands or contracts instantaneously with temperature changes, making or breaking the totally-enclosed electrical contacts.*

Design engineers have put THERMOSWITCH units to work everywhere that temperature control is vital — in planes . . . factories . . . ships . . . hospitals . . . food-processing plants . . . homes . . . laboratories. The list of THERMOSWITCH applications is virtually endless. So is the list of physical ordeals the units have survived and the high performance standards they've met.

When tested alongside bulb-type and enclosed bi-metallic thermostats under identical conditions, THERMOSWITCH units have overwhelmed both with performances like these:

- reaction speed, four to nine times as fast;
- heat-responsive area, three to six times as large;
- heat-transfer path, only one-third to one-sixth as long;
- temperature differential, only one-tenth to one-nineteenth as great;
- vibration-sensitivity, only one-twelfth to one-eighteenth as great;
- shock-sensitivity, only one-tenth to one-eighteenth as great;

FENWAL THERMOSWITCH UNITS may solve your temperature control problems, too. Sensitive, tough, and accurate — they have been put to work by designers wherever temperature control is vital. Over 25,000 variations of the THERMOSWITCH unit are available. Write for THERMOSWITCH folder.

Added to these points of superiority are such demonstrable features as uniformity of sensitivity throughout the operating range, built-in temperature anticipation, enclosed tamper-proof assembly, direct radiant heat reception, and an operating range from −100°F. to 600°F.

Other ranges are available, too. The point at which a unit makes or breaks a circuit is determined by a set screw easily adjusted in the field.

There's a Fenwal sales engineer ready to help you apply THERMOSWITCH units to your particular heat control problems — ready with over 25,000 variations. Write Fenwal for his name and for complete specifications. **Fenwal Incorporated, 21 Pleasant Street, Ashland, Mass.**

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the Beryllium Copper ROLLPIN®

Strong . . . highly resistant to corrosion . . . nonmagnetic . . . extremely conductive

Now you can use Rollpin to cut assembly and maintenance costs in a whole new group of applications. A new line made of beryllium copper, one of the strongest of the copper base alloys, opens the door to a wide variety of uses where resistance to corrosive attack, good electrical properties and other unusual characteristics are required. These slotted tubular copper spring-pins can be used in assemblies that range from plumbing fixtures to electrical instruments, particularly in conjunction with other copper base alloy components.

Rollpin has already established its ability to replace taper pins, straight pins and set screws; to serve as a rivet, dowel, hinge pin, cotter pin or stop pin . . . eliminating special machining, tapping and the need for hole reaming or precision tolerances. Driven into a hole drilled to normal production standards, it locks securely in place, yet can be readily drifted out and reused whenever necessary.

Rollpin is available in beryllium copper from .062″-diameter to .250″-diameter, and in steel and stainless steel up to .500″-diameter.

ELASTIC STOP NUT (ESNA) **CORPORATION OF AMERICA**

Dept. R35-12, Elastic Stop Nut Corporation of America
2330 Vauxhall Road, Union, New Jersey

Please send me the following free fastening information:

☐ Data on beryllium copper Rollpin

☐ Here is a drawing of our product. What self-locking fastener would you suggest?

Name_____ Title_____

Firm_____

Street_____

City_____ Zone_____ State_____

GRAMIX® BRONZE BEARINGS AND IN NEW Sunbeam PRODUCTS

GRAMIX® ALLOYS

(PRODUCT OF POWDER METALLURGY)

The new Sunbeam Mixmaster Junior* does kitchen mixing chores quickly and efficiently and one of the important factors in its fine performance is the use of GRAMIX bearings on the beater spindle shafts. These sintered metal bearings, which are produced from GRAMIX Grade 81 alloy, are oil-impregnated for self-lubrication and are quiet running in operation. One of the outstanding features of these GRAMIX bearings is the fact that they are exceptionally long in relation to the comparatively small diameter. Yet there is no taper or "bell mouth" effect present and tolerances are held to .001 on both the ID and OD. The bearing offers maximum load-carrying surface throughout its length. In addition, Sunbeam engineers have found that GRAMIX gives them a controlled, consistent density in all sections of the bearing. This is another case where GRAMIX bearings have been specifically engineered and produced to fit the needs of the application. Can the same be done for your products?

**Made and guaranteed by the Sunbeam Corporation, Chicago, Illinois*

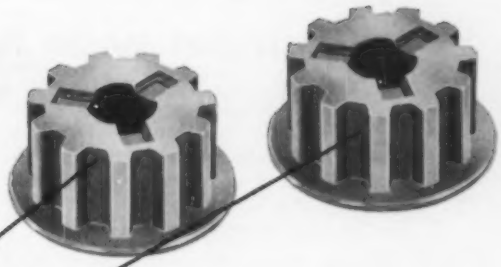
117

THE UNITED STATES

GRAPHITAR® CARBON-GRAPHITE • GRAMIX® SINTERED METAL PARTS • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES

GRAMIX® IRON SPROCKETS

PROVE VERSATILITY OF



In the new Sunbeam twin blade electric lawn mower, power is transmitted from the motor to the cutting blades via cog belt drives. Among the most important parts in this power transmission system are a pair of drive sprockets which must stand up under hours of rugged operation. For these critical parts, Sunbeam Corporation engineers have specified GRAMIX sintered metal sprockets produced to their exact specifications from GRAMIX iron alloy 78. This dual purpose part acts as both a bearing and a sprocket. The excellent bearing characteristics of this GRAMIX alloy eliminates need for special inserts etc., yet the sprocket itself withstands shock loading and maintains a constant coefficient of friction. The contour of the sprocket teeth is maintained under the most severe operating conditions. Additional benefits that Sunbeam engineers have found in GRAMIX include the compatibility of GRAMIX with the belt material and the fact that there is less operational noise. Again, this is a case where the GRAMIX process has produced a part specifically engineered to meet exact product requirements . . . why not investigate the advantages of GRAMIX parts for your designs?

WRITE FOR THIS BOOK

Because GRAMIX parts are die-pressed to shape, then sintered, they are usually much more economical than machined parts. Tolerances as close as .0005″ can be held, and the parts oil-impregnated for self-lubrication. Other facts of value to the manufacturer and the design engineer are contained in GRAMIX Engineering Bulletin No. 21. Write today to The United States Graphite Company, Saginaw, Mich.

GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW, MICHIGAN

MICRO SWITCH Precision

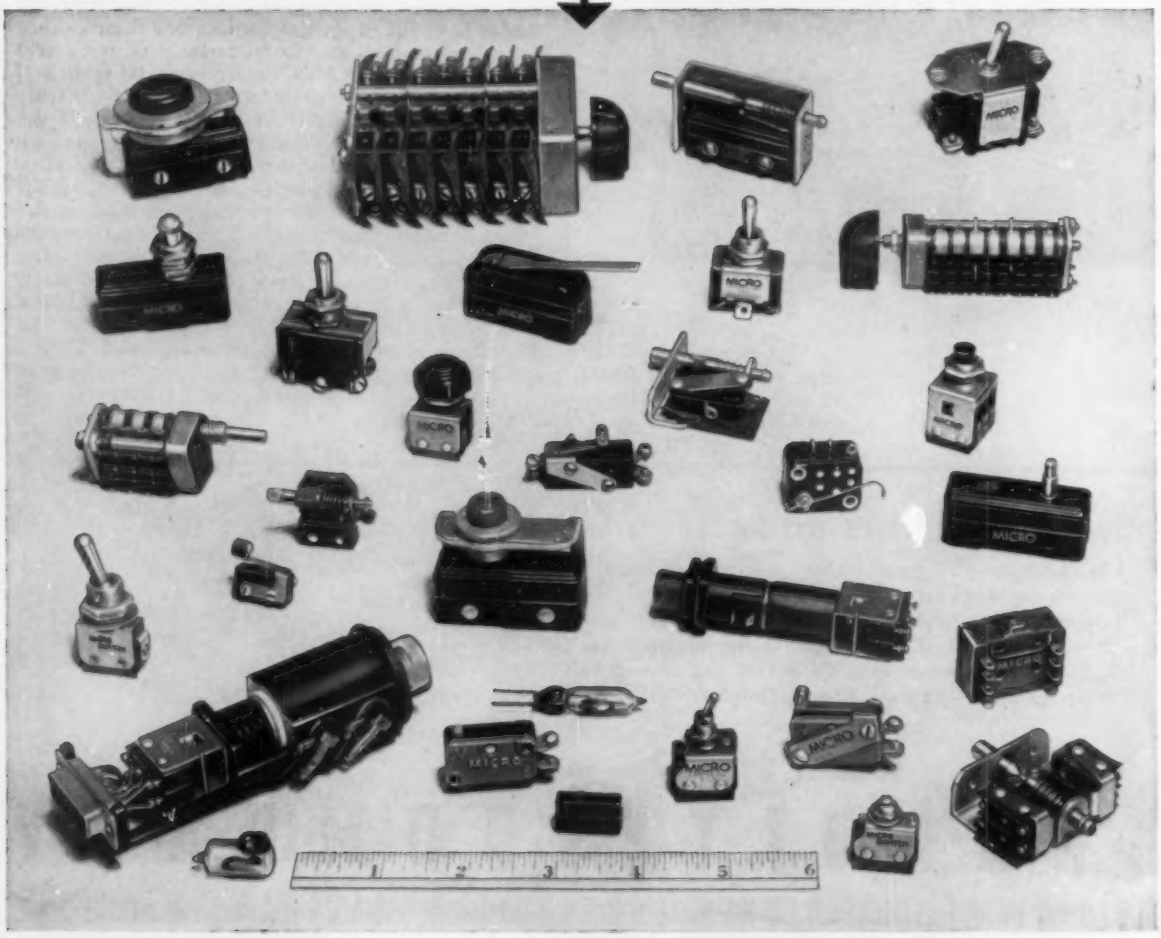
...FIRST IN PRECISION SWITCHING

small... accurate... reliable... precise
MICRO SWITCH Precision Switches meet wide range of modern electronic control requirements

Design engineers find MICRO SWITCH precision switches to be ideal components for computers, high speed switching devices and other industrial devices.

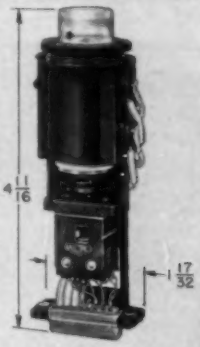
Whether the requirement is for an individual switch—or a complete switch assembly—MICRO SWITCH Engineering is at your service. Development of precise, reliable switching components is our sole business. Our switching specialists have met successfully many knotty problems of switch design and application. This long, practical experience will save YOU time and money.

A call to the nearest MICRO SWITCH branch office will put MICRO SWITCH Field and Factory Engineering to work on your specific problem. This cooperation can be your short cut to improved design.



Switches have uses unlimited

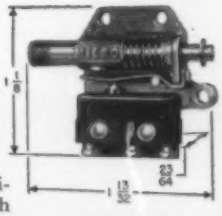
3-LIGHT PUSH BUTTON SWITCH FOR COMPLEX CONTROL PANELS



Here is a new, unique indicating push button switch which lights in three different colors. It is the latest MICRO SWITCH development for use in complex console panels. This compact assembly is ideal for applications where absolute dependability is required. It has a reliable operating life through hundreds of thousands of operations. Use is simplified by a pre-wired connector plug.

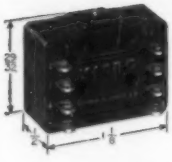
(Send for Data Sheet 110)

SUBMINIATURE SAFETY SWITCH DEVICE FOR HAZARDOUS EQUIPMENT



This MICRO SWITCH Subminiature door interlock switch assembly is designed for use as a safety device on such hazardous equipment as radio, radar, and X-ray cabinets. Installed on the cabinet door the switch automatically cuts off the power circuit when the service door is opened. Assembly shown uses a MICRO SWITCH Subminiature basic switch with single-pole, double-throw contact arrangement.

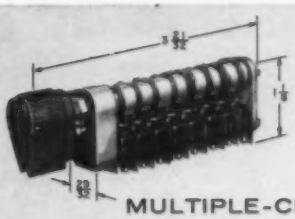
(Write for Data Sheet 108)



FOUR-CIRCUIT SWITCH FOR CONTROL OF COMPLEX CIRCUIT

Here is a four-circuit double-break switch for simultaneous control of four isolated circuits. This small switch is ideal in complex circuit applications where space and weight are prime factors in switch selection. Two snap-action springs are operated with each actuation of the plunger. This provides quick make and break of the contacts in each of the four double-break circuits. Electrical rating is 10 amperes 115-230 volts a-c; 10 amperes 30 volts d-c.

(Write for Catalog 78)

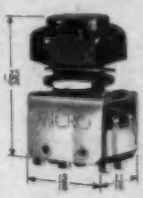


SUBMINIATURE ROTARY SELECTOR SWITCH FOR MULTIPLE-CIRCUIT CONTROL

This assembly is an 8-gang, 8-position rotary selector switch. It consists of 8 single-pole, double-throw Subminiature basic switching units operated by cams on a common shaft. Any combination of the 8 basic switching units may be actuated in any of the 8 positions if cams are set to specifications at the factory. Variations with from 2 to 8 single-pole, double-throw basic switches are available.

(Write for Catalog 75 "Subminiature Switches")

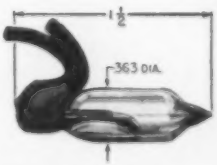
SEALED PUSH BUTTON SWITCH FOR PANEL MOUNTING APPLICATIONS



This MICRO SWITCH push button switch for panel mounting is outstanding because of its very small size and ease of installation. After the push button is mounted on a panel, the switching unit can be wired and then easily snapped into place on the end of the button assembly behind the panel. In addition, the push button is sealed to keep dirt and moisture from penetrating to the back of the panel. Switch has operating force of 3 lbs., weighs but .05 lbs.

(Write for Catalog 75 "Subminiature Switches")

SMALL HONEYWELL MERCURY SWITCH MEETS SMALL LOAD CIRCUIT DEMANDS



The small Honeywell Mercury Switch shown here is especially designed for reliable service in low-energy circuits. This switch meets the requirements of applications where space and economy are critical factors. Mercury switches are widely used in animated displays, control and indicating devices, home freezer units, alarms and hundreds of other tilt-motion, low-force applications. Ratings available down to micro-volt, milli-ampere ranges.

(Write for Catalog 90 on "Mercury Switches")

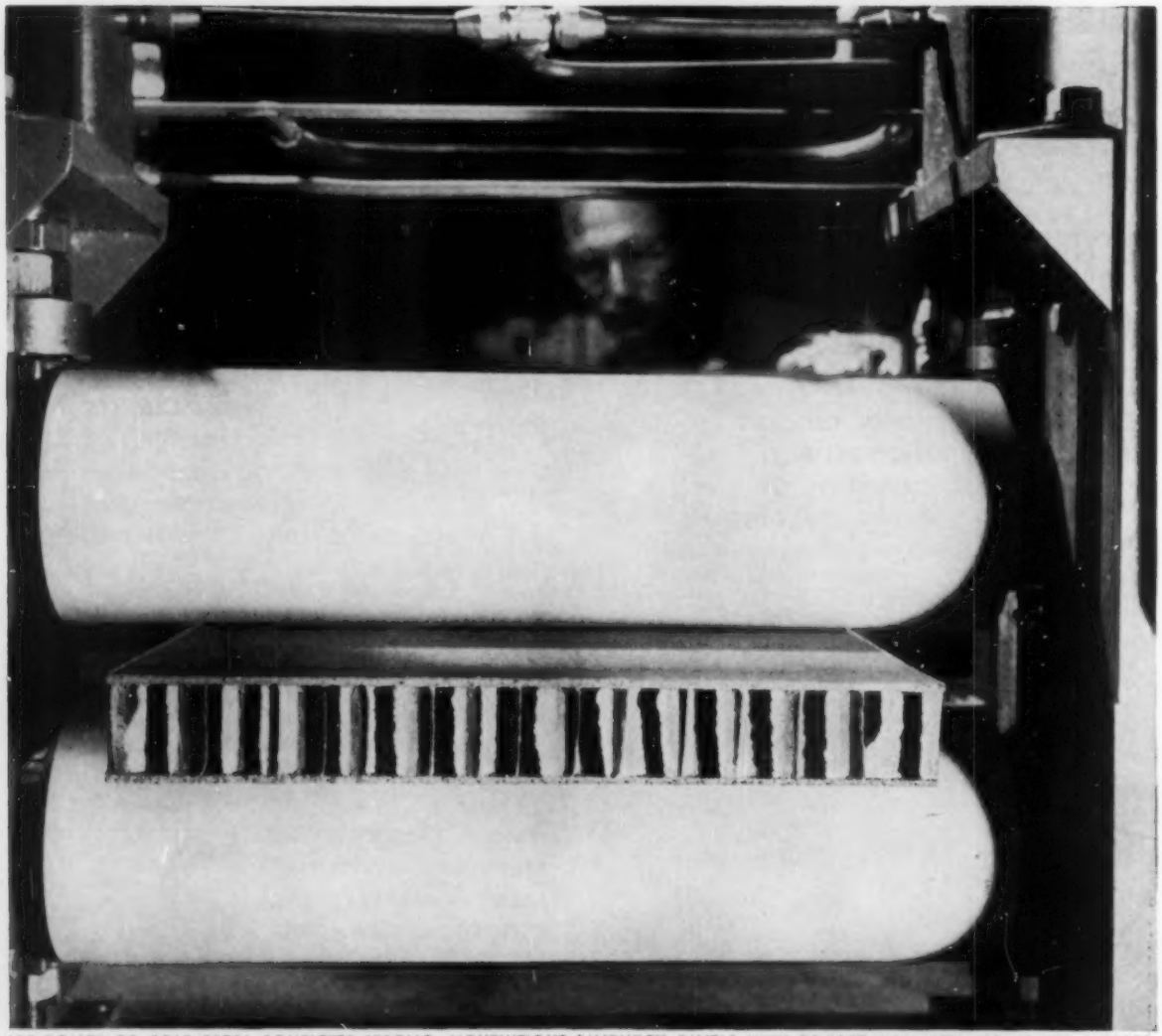
MICRO SWITCH, a division of Honeywell, is the pioneer in the manufacture of precision snap-action switches.

MICRO SWITCH

A DIVISION OF MINNEAPOLIS-HONEYWELL REGULATOR COMPANY

In Canada, Leaside, Toronto 17, Ontario • FREEPORT, ILLINOIS

For fast, cold sandwich bonding ...3M Adhesive EC-1357



NIP ROLLER OR COLD PRESS COMPLETES STRONG, LIGHTWEIGHT SANDWICH PANELS WITH EC-1357. YOU NEED NO HEATED PRESSES.

Gain the speed and economy of cold bonding! Fabricate sandwich panels for non-load bearing uses with 3M Adhesive EC-1357.

This high-strength, flexible adhesive bonds sandwich panels without clamps or heated presses. You force-dry the solvent out of the adhesive before bonding. Cold press or nip roller finishes the job. You get maximum immediate strength. And EC-1357 builds up even more strength with age as it cures at room temperatures.

Because it is dark in color, EC-1357 absorbs drying heat fast. Thus it cuts production time, allows continuous movement from adhesive spraying to finished panel. EC-1357 resists moisture and normal temperatures, too. For load-bearing panels, investigate 3M Adhesive EC-1177.

SEE WHAT 3M ADHESIVES CAN DO FOR YOU!

Consult 3M research. Contact your 3M Field Engineer. Or for information and free literature, write on your company letterhead to: 3M, Dept. 71, 417 Piquette Ave., Detroit 2, Mich.

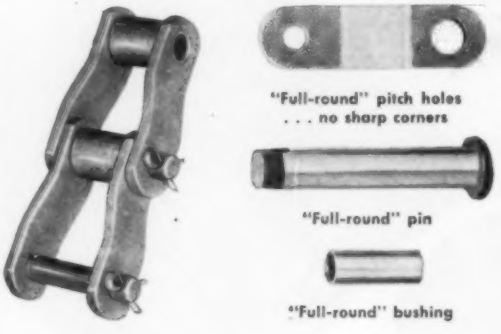
PRODUCT OF 3M COMPANY RESEARCH

MINNESOTA MINING AND MANUFACTURING COMPANY · ADHESIVES AND COATINGS DIVISION

417 PIQUETTE AVE., DETROIT 2, MICH. • GENERAL SALES OFFICES: ST. PAUL 6, MINN. • EXPORT: 99 PARK AVE., N.Y. 16, N.Y. • CANADA: P.O. BOX 757, LONDON, ONT.

"Stress raisers" eliminated by Link-Belt LXS chain design

LXS "FULL-ROUND" DESIGN



"FULL-ROUND" DESIGN eliminates stress concentration points. Heat treatment of all parts adds even greater strength and extra wear life to selected steels. Accurate control of these processes avoids brittleness, poor wear values and low tensile strengths . . . and assures uniformity.

Large pins, bushings mean ample live bearing area for long life

For long life under severe conveyor and drive conditions, Link-Belt LXS chain provides extra strength, increased wear resistance and wider application flexibility. This fabricated steel roller chain incorporates many advanced design and manufacturing refinements, resulting in superior ruggedness and accuracy.

Eliminate weak points

"Full-round" design does away with stress concentration points most frequently subject to failure . . . provides maximum live bearing area between pin, bushing and sidebars. As a result, stress is distributed evenly, increasing chain life.

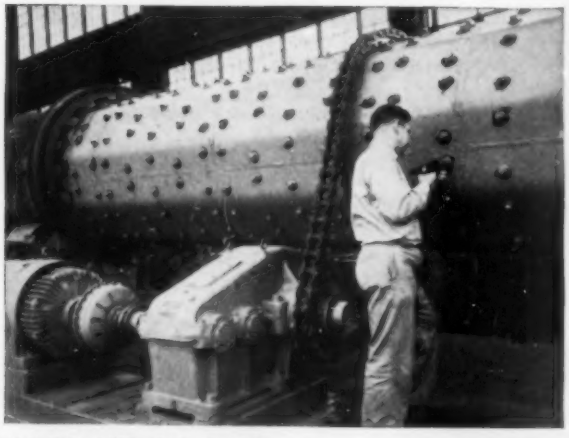
Pins and bushings are accurately sized for controlled press fit, preventing rotation in sidebars. Made from selected bar steel, sidebars are carefully machined for proper pitch hole size and for maintaining firm, tight press fit of pins and bushings. This assures close control of pitch and proper chain length after assembly.

Hardening extends life

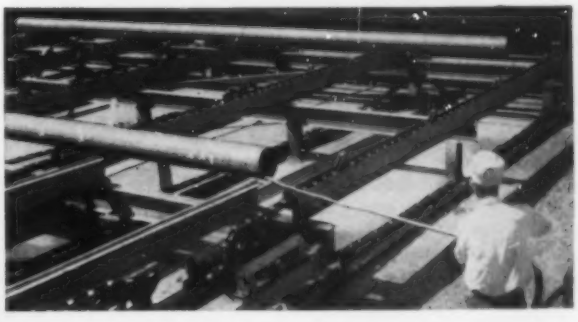
Another Link-Belt long-life extra is the controlled hardening of selected steels used in the manufacture of LXS chain. Pins, for example, are made from a tough steel, specially treated for high strength in shear and for maximum wear value. Bushings are properly hardened to shrug off shock and resist wear.

Rollers are accurately machined to assure proper operating clearances and free-rolling action. Controlled hardening gives them the necessary resiliency and durability.

LXS especially popular for exposed drives, high impacts



Link-Belt LXS chain is the long-life answer for exposed drives, abrasive and high-impact conditions. Its large, live bearing area reduces cutting action of abrasives because load is spread over a broad area.



LXS chain provides extra strength, wear-life for heavy-duty conveying

Link-Belt LXS chain has real stamina—as shown in this conveyor application for handling 1000-pound, 40-foot lengths of steel pipe. Thanks to accuracy of pitch and attachment spacing, plus close matching of multiple strands, LXS has the added strength and wear life for the extra-long conveyors so popular in today's move to mechanization.

For help with any chain problem call your nearby Link-Belt office. Send for 342-page catalog 950 covering the complete line of standard Link-Belt products for conveying and power transmission.

LINK-BELT

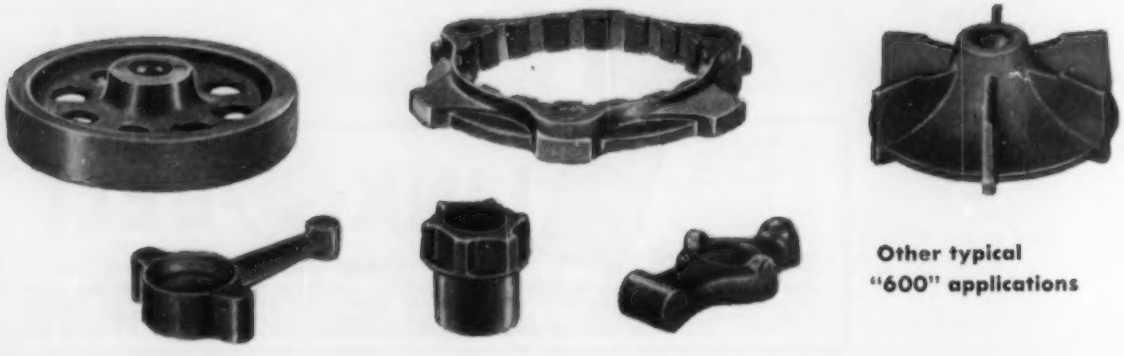
CHAINS AND SPROCKETS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 14,258

MUELLER BRASS CO. 600 SERIES BRONZE

the main working part in the smooth and OCEAN CITY SPINNING REELS

600 Series gears prove ideal in heavy duty salt water models 300, R300, and 320 in which corrosion resistance and high strength are important.



Other typical "600" applications

FORGED GEAR powerful

The Montague-Ocean City Rod & Reel Co. of Philadelphia is proud of the fact that many fishermen are calling their famous Ocean City "300" series spinning reels "the most dependable spinning reels in America." Such praise justifies the very best components in a product—like the corrosion-resistant Mueller Brass Co. "600" alloy gear. Provides its own shaft and has an integral clutch which takes the driving force from the handle, and incorporates a cam which provides the oscillating motion of the spool for cross-winding the line. Bronze was chosen because of the need for maximum strength, long wear, and because it is such an excellent bearing material. This application dramatically points up the valuable properties of Mueller "600" series alloys.

There are countless applications of Mueller "600" series bearing alloys. Find out how you can utilize one or more of them in YOUR products. Because forgings can be made closer to the finish size in "600" series alloys than can sand castings, there is less waste, greater speed in finishing.

• WRITE TODAY FOR THE ENGINEERING MANUAL YOU NEED

Mueller Brass Co. Forgings Engineering Manual H-58565 ☐

Tuf Stuf Aluminum Bronze Alloys Engineering Manual H-58563 ☐

600 Series Bearing Alloys Engineering Manual FM-3000 ☐

Copper Base Alloys in Rod Form Engineering Manual FM-3010 ☐

METALS AND ALLOY REVIEW

by FRANK M. LEVY

Vice-President and Director of Research

Recently Ray Engelgau, who heads our statistical quality control procedures, and Amos Armitage from our machining department met in my office and we had a very interesting discussion on our new "S-C" rod. The term "S-C" is derived from the fact that it is produced from billets that are cast semi-continuously. In addition, we use the letters "S-C" to indicate its "super cutting" qualities which is one of the outstanding characteristics of this rod. We have definitely proved these qualities in some very exhaustive tests, one of which I'd like to tell you about here.

Experience has shown that it is difficult to control dimensions within close tolerances on machine parts involving internal forming operations. Amos had run into exactly that trouble with a certain hydraulic fitting made from rod that required a fairly close dimensional tolerance on the internal formed diameter. So, we decided to make a comparison test by machining the part from rod made by the conventional method and from rod produced by the S-C process. When rod made by the conventional method was machined, the parts could not be held within the specified tolerance range. The same machine, the same tooling and the same machine operator were used in this test, and when S-C process rod was substituted, the machine parts were well within the required tolerance range.

In addition, I just received a letter from a well-known equipment manufacturer who has been running tests on S-C rod. They reported that the incidence of tool trouble per 1000 forgings machined from S-C rod were approximately half that of forgings made from conventional rod. We think that is pretty good evidence that the rod made by our semi-continuous process is exceptionally uniform by all standards. Incidentally, our new billet casting department is quite a model of automation and has a number of interesting processes and features. Anytime you happen to be in our area we would be more than happy to show you through and explain the many points of this process that gives us what we firmly believe to be the best possible rod available today which of course is reflected in the quality of our forgings.

If you would like a folder that fully covers our semi-continuous process, just drop me a note and I'll see that one is sent along to you promptly. In the meantime, we'd like to have you investigate our super-cutting S-C rod because we think it will improve your product quality—and we've got the alloys to do most anything to meet the most exacting demands.

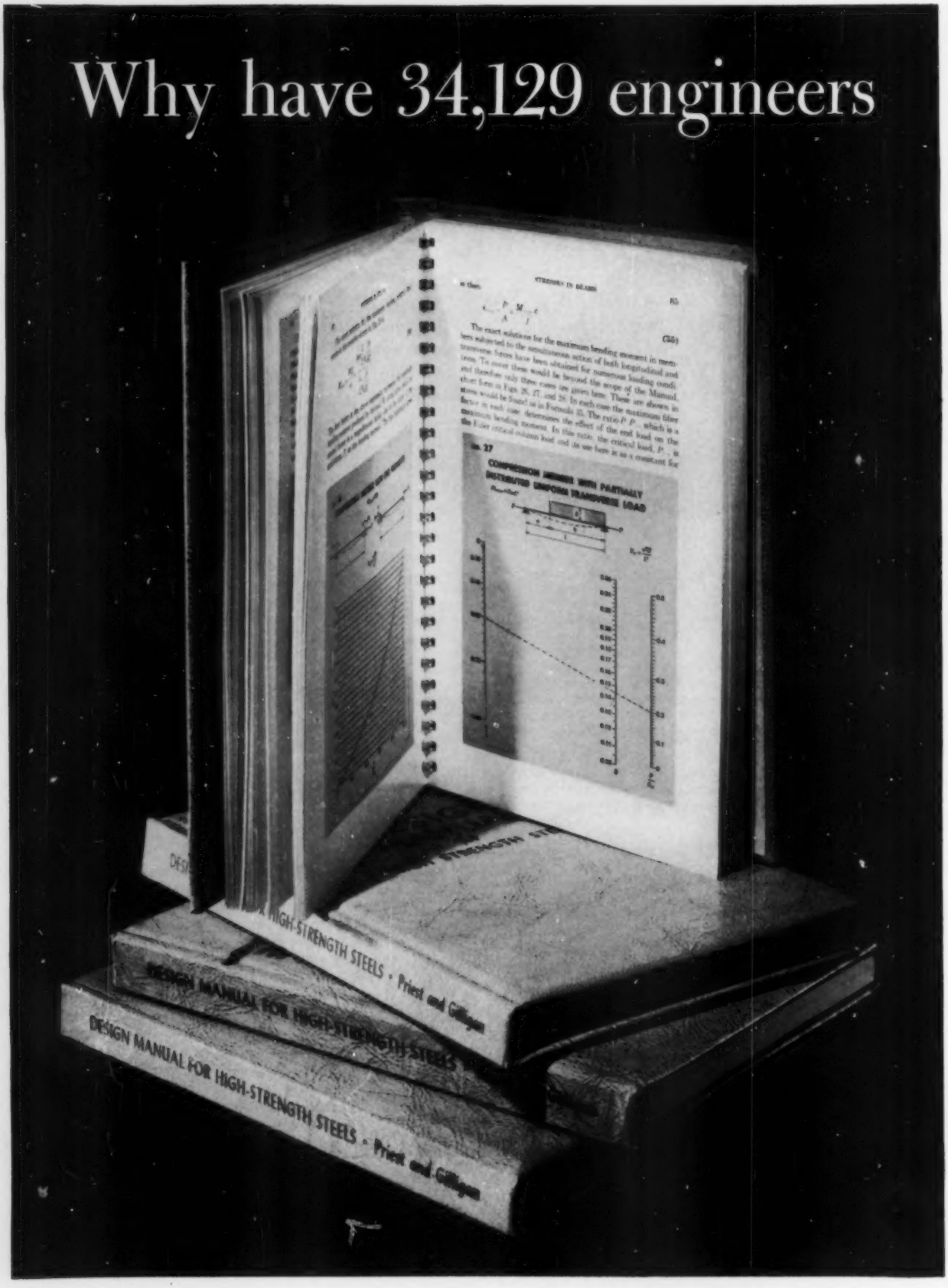
Thanks for your time.

MUELLER BRASS CO.

PORT HURON 22, MICHIGAN

199

Why have 34,129 engineers


DESIGN MANUAL FOR HIGH-STRENGTH STEELS • Priest and Gilligan
DESIGN MANUAL FOR HIGH-STRENGTH STEELS • Priest and Gilligan

written us for copies of this unusual book?

Every day we receive an average of 70 requests for our "Design Manual for High Strength Steels." This, despite the fact that in the past two years we have distributed 54,096 of these Manuals—enough to make a stack three times as high as the Empire State Building.

Requests have come not only from design engineers for whose use this book was primarily written, but from men signing themselves as Research Engineer, Project Director, Development Engineer, Design Analyst, Process Engineer, Test Engineer, Mechanical Engineer, Chief Engineer, Methods Engineer, Materials Engineer, Marine Engineer, Industrial Engineer, Electrical Engineer, Aeronautical Engineer, Purchasing Agent, Plant Manager, Chief Inspector, President, and so on and so on. We even had one from a Chairman of the Board. *(Looks like a lot of men besides design engineers are vitally interested in High Strength Steels and want to know how, when, where and why to apply them.)*

While most of these requests have come from all parts of the United States and Canada, an amazing number have reached us from England, Germany, Belgium, France, Italy, South Africa, India, Japan, South America, Australia and New Zealand. *(Seems that no country is so remote that it hasn't heard the good word.)*

What's in this book that makes it such a "must have" for those who have seen it or merely heard about it?

We like to think that the "Design Manual" is finding its place on so many engineers' desks and book shelves—not because it is a costly book, free for the asking—but because it *contains information nowhere else available* and never before presented so clearly and comprehensively.

For here, in one volume, the design problems of tension, compression, shear, beam stress, deformation, and deflection are covered in detail, the fundamental characteristics of high-strength low-alloy steels that result in economies to the user are described, the principles of designing against corrosion, and the application and advantages of formed sections are authoritatively discussed.

. . .

Complete with tables, formulas and basic data covering every facet of this important subject, the 174-page "Design Manual for High Strength Steels" is a book that you will find invaluable in designing your product for greater efficiency and economy. A fourth printing is now on the presses. We will gladly send you a free copy if you will write — *on your company letterhead*, giving your title or department—to United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

UNITED STATES STEEL

SQUARE D OIL-TIGHT PUSHBUTTONS

Everybody's Ahead with

THOSE WHO *Build* MACHINES

The *completeness* of Square D's pushbutton line makes a lot of sense to machine builders. Since any operator can be used with any contact block, every conceivable combination can be obtained with a minimum stock of packaged units. Another thing they like...the customer's enthusiastic approval of Square D control on the equipment they buy.

OIL-TIGHT OPERATORS

MOMENTARY CONTACT Guarded button in 7 colors.

MUSHROOM BUTTON 1⅜" or 2¼". Momentary contact. 7 different colors.

SELECTOR SWITCH 2 or 3 position with 4 different cams.

COIN OPERATED SELECTOR SWITCH Available in same selection as standard type.

KEY OPERATED SELECTOR SWITCH Discourages unauthorized operation.

SELECTOR PUSHBUTTON combines selector switch and pushbutton. 2 or 3 position in red or black.

PADLOCK ATTACHMENT Latch type. For momentary contact buttons. Locks "off" position.

PADLOCK ATTACHMENT Cover type. Prevents depressing button.

MAINTAINED CONTACT ATTACHMENT Used with two operators and one contact block.

SELECTOR SWITCH LOCK-OUT Permits switch to be locked in any one of three positions.

WOBBLE STICK OPERATOR for momentary pushbutton operator. Ideal for emergency stop with pendant station.

NEOPRENE CAP for momentary contact button. Prevents liquids, dust and grit from working into pushbutton operator.

NOW...EC&M PRODUCTS ARE A PART OF THE SQUARE D LINE!

SQUARE D COMPANY

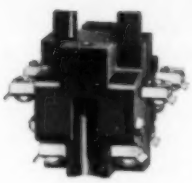
THIS MOST COMPLETE HEAVY DUTY LINE!

AND THOSE WHO *Buy* THEM

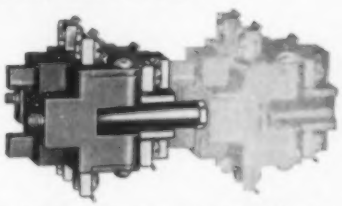
Performance and long life rank high with the men who buy and maintain the machines. Square D pushbuttons, designed to JIC and NMTBA standards, have been proven by severe tests involving millions of operations. They offer still other features...generous wiring space and exclusive "Slide and Swing" enclosure covers for easier, faster installations when machine operations are changed.

CONTACT BLOCKS and PILOT LIGHTS

Single Pole N.O. and N.C. Contacts.



Duplex N.O. and N.C. Contacts.

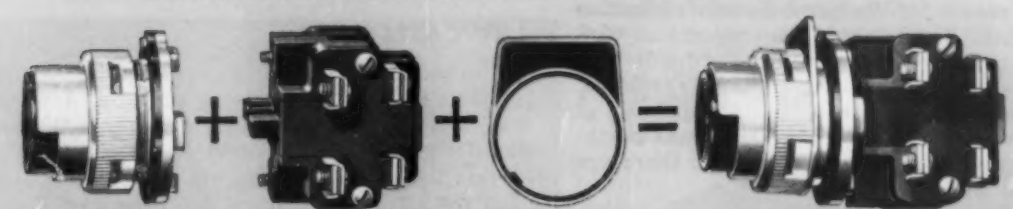


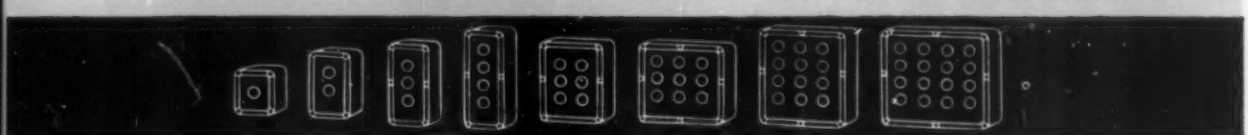
Tandem Operation. Duplex N.O. and N.C. Contacts with extended stems for combination with another block.

Duplex N.O. and N.C. Contacts with one N.O. circuit closing ahead of the other. Designed for 2-speed or sequence operations.

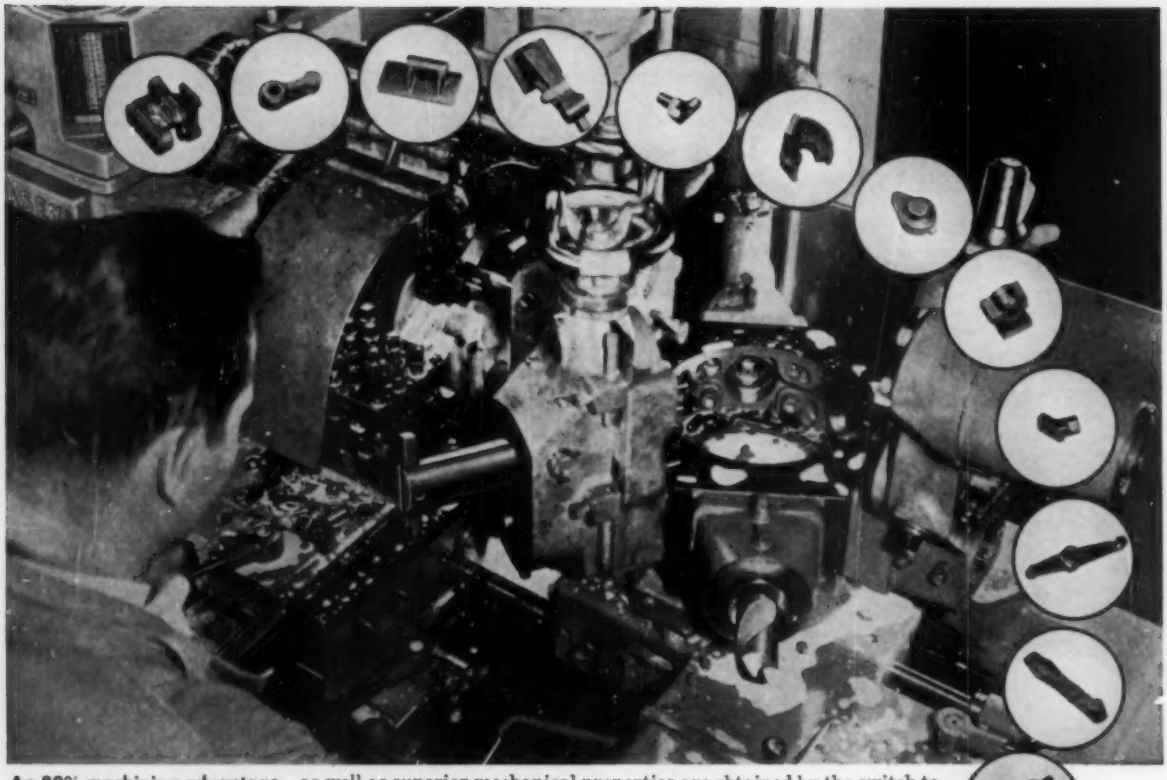
PILOT LIGHT. Generous illumination and wide-angle visibility. Greatly reduced filament burn-outs. No loosening of lamp under vibration. Six colors—red, amber, green, blue, white, clear.

ANY OPERATOR WITH ANY CONTACT BLOCK





ENCLOSURES AVAILABLE FOR 1 TO 16 UNITS



An 80% machining advantage...as well as superior mechanical properties are obtained by the switch to ductile iron castings for this turret lathe and other machine tools produced by The Warner & Swasey Company, 5701 Carnegie Avenue, Cleveland 3, Ohio. Shown above are typical parts now cast in ductile iron to cut both production and maintenance costs. Combining the best features of cast iron and steel, ductile iron is easy to cast and machine, yet provides high strength and toughness.

Warner & Swasey improves 275 turret lathe parts with ductile iron

Clutch plates, hinges, levers, tool holders, wrenches . . . 275 parts in all . . . are now specified in ductile iron for Warner & Swasey turret lathes.

MONEY-SAVING MACHINABILITY

was one reason for Warner & Swasey's adoption of ductile iron. The machine shop reports an 80% advantage in machining operations for ductile iron castings over the malleable iron parts they replaced. The ductile iron castings cut readily and evenly at hardness levels of 170-190 BHN. This means worthwhile savings in machining costs, but there are other advantages, too.

HIGH MECHANICAL PROPERTIES

Ductile iron castings provide a combination of strength, hardness and toughness that makes them dependable for severe use in machine tools. Specifying ductile iron type 60-45-10, Warner & Swasey finds the castings provide an average yield strength of 56,250 psi and elongation of 16%. These parts also have a high level of wear resistance.

AND CASTABILITY

The good fluidity of ductile iron permits filling intricate molds . . . improving quality of the castings and quantity of output regardless of wide variations in section thickness.

You, too, can cut machining costs and improve your products or equipment by using ductile iron castings. Get all the facts in "DUCTILE IRON, The Cast Iron THAT CAN BE BENT." Write for your copy now.

ductile iron . . . the cast iron that can be twisted and bent

The INTERNATIONAL NICKEL COMPANY, Inc.
67 Wall Street, New York 5, N. Y.

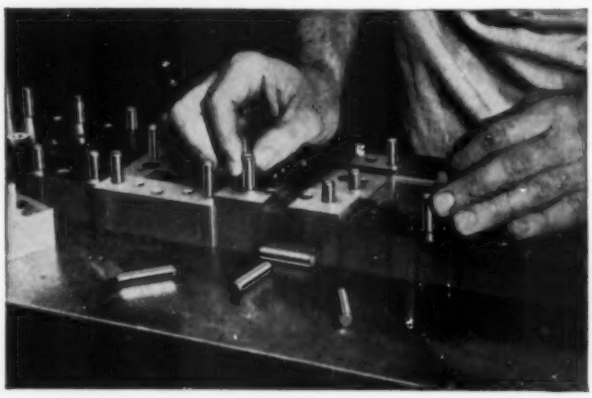
"STOCK ANSWER"
to many a design problem

ALLEN DOWEL PINS

ALLEN DOWEL PINS are being profitably employed in a thousand and one ingenious ways beyond their conventional applications in tool and die work — as economical roller bearings, as axles, precision plugs, hinges and wrist pins to name a few.

If you have an application that will utilize the great strength, accuracy and fine finish of Allen Dowel Pins, you can save substantially on the cost of your product — because you can secure them at favorable prices right from your Allen Distributor's stock.

Check the quick facts at the right and write directly to Allen's Engineering Department for further technical information.



SPECIFICATIONS

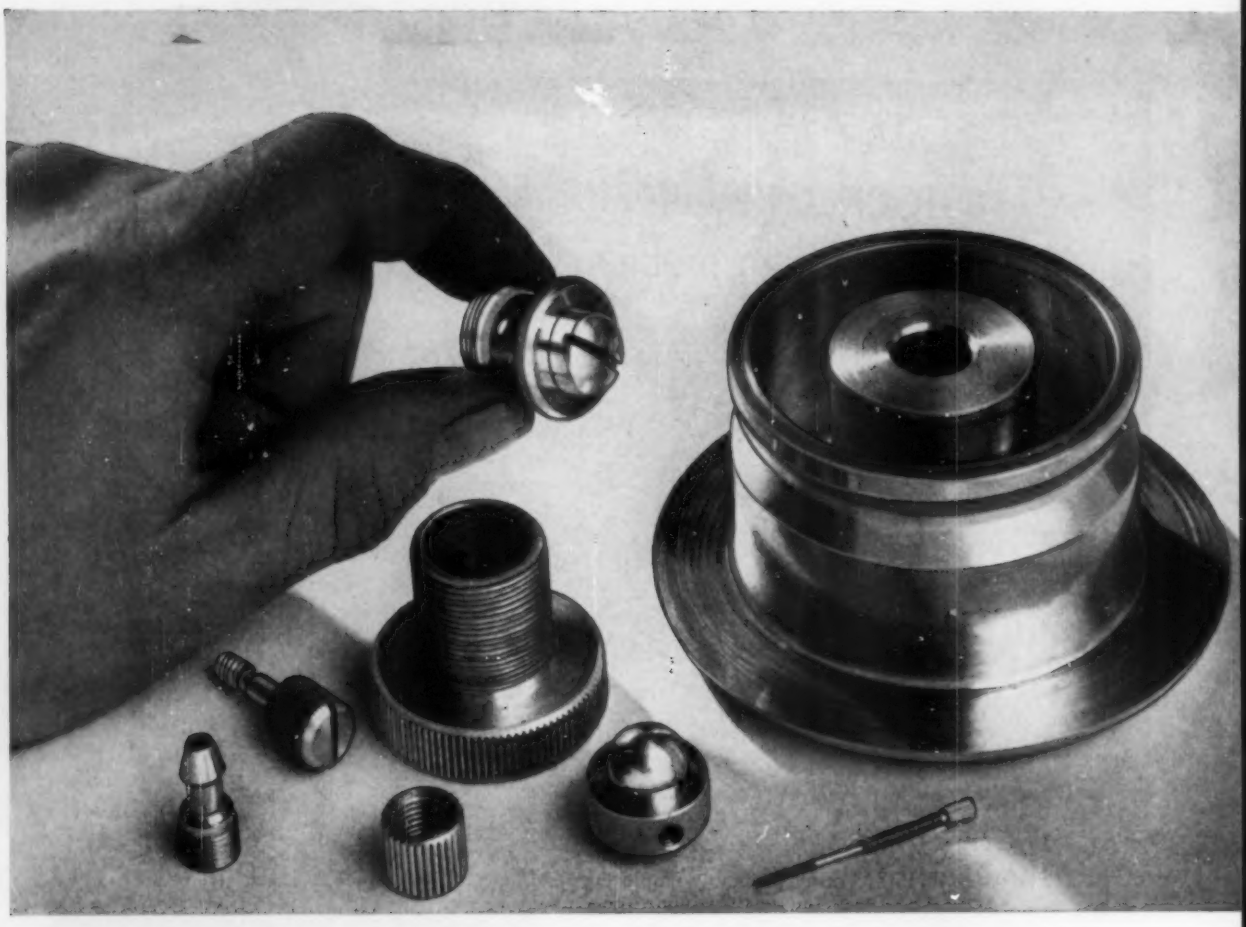
- Made from Allenoy heat treated steel. Surface hardness 62-64, Rockwell C scale; core hardness 52-54. Case depth .010″ to .020″ depending on size.
- Single shear strength 160,000 to 180,000 p.s.i.
- Surfaces precision ground to ± .0001″ with micro-inch finish of 6 RMS max.
- Sizes: Diameters, ⅛″ to 1″. Lengths, ⅜″ to 6″.
- Two standard oversizes — .0002 for press fits between mating parts, or .001 for repair work, or holes machined oversize.

ALLEN HEAD

ALLEN

MANUFACTURING COMPANY

Hartford 6, Connecticut, U.S.A.



Typical parts machined by Taylor Instrument Companies from Alcoa Aluminum Screw Machine Stock

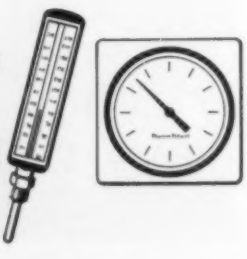
HOW TAYLOR INSTRUMENTS* GET A LIFT AND A LONG LIFE FROM ALCOA SCREW MACHINE STOCK

Where measurements must be precise, you'll find Taylor Instruments . . . insuring a jet pilot's safe descent by parachute . . . warning a ship's captain of changing weather . . . telling the doctor your temperature and blood pressure. In everyday life, and in thousands of industrial plants, Taylor Instruments have helped America measure its progress since 1851.

What are Taylor's requirements for screw machine parts? Precision, naturally. Corrosion resistance is also important since many Taylor Instruments are installed where maintenance is virtually impossible. Because many Taylor products, like your home thermometer, are mass-produced, cost is exceptionally important in the selection of a screw machine stock.

With these requirements in mind, read why Taylor Instrument Companies use Alcoa® Aluminum Screw Machine Stock. See if their experience plus the inescapable economics of aluminum versus brass doesn't dictate a hard look at all your screw machine parts. For competent technical help in making such an analysis, simply call your local Alcoa sales office listed under "Aluminum" in your classified phone book. Aluminum Company of America, 865-A Alcoa Building, Pittsburgh 19, Pennsylvania.

*Taylor
INSTRUMENT COMPANIES

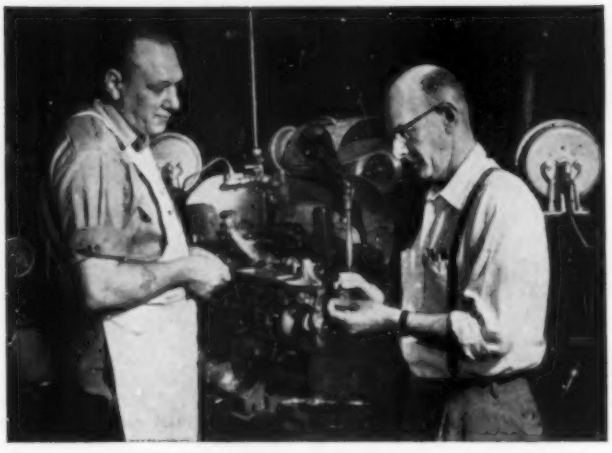


IN PURCHASING

Asst. Purchasing Agent, J. R. Mahan, says, "Dependability is the single most important requirement of a supplier. This we get in full measure from Alcoa. Quality has always been dependable. Deliveries have come when promised. Service and technical help are always available to us and their answers are right. We find this Alcoa dependability also applies to Alcoa distributors from whom we get prompt delivery."

IN METHODS ENGINEERING

H. D. Klitgord, Manager, Methods Engineering Department, says, "We have a continuous cost study of materials for all of our screw machine parts. Equal or better performance has been our criterion in every instance where money could be saved. We are saving $100,000 per year by using aluminum. Our conversion at present is about 40% and we anticipate an increasingly greater use of aluminum bar stock."



IN PRODUCTION

Mr. H. Bubel, Group Leader, Automatic Screw Machine Department, says, "We are machining aluminum at the maximum production rates possible. Alcoa technical people have been of great assistance to us in recommending cutting oils and tools, and helping us maintain our close tolerances and fine finishes."

Your Guide to the Best in Aluminum Value

How FLEXLOC clinch nuts save production time

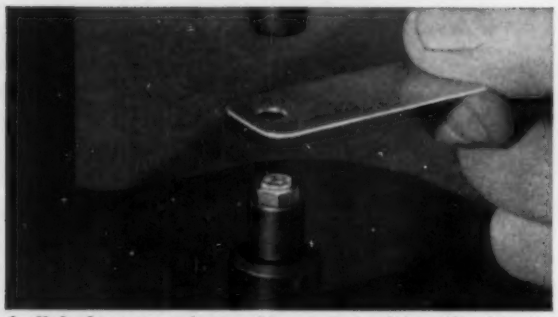
If you are building assemblies of thin-section materials, you can make secure bolted connections with FLEXLOC clinch nuts. Use them instead of cage nuts, anchor nuts and weld nuts. They are easy to install—no riveting or welding is required.

When you design with 1-piece, all-metal FLEXLOC clinch nuts, you simplify production operations by eliminating complicated nut-and-lockwasher assemblies. And the nuts cannot fall off or get lost during maintenance operations.

When you thread in a screw, the FLEXLOC locks it wherever wrenching stops (as soon as 1½ screw threads or more project through the locking section). Locking action is positive and dependable. No matter how many times your product must be reassembled during maintenance or repair, the FLEXLOC holds securely every time. Its locking life is virtually unlimited. It cannot be loosened by vibration.

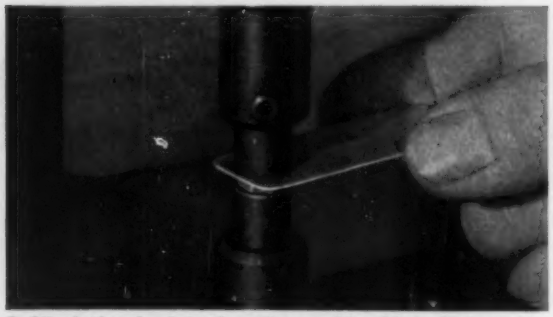
Standard FLEXLOC self-locking clinch nuts come in sizes #4 through ¼ in., for use in materials from ½ to 3/16 in. thick. They are made in alloy steel, stainless steel, brass and aluminum. FLEXLOC clinch nuts and clinching tools are available through your authorized industrial distributor. Call him today. Write us for complete specifications, or for information about your special locknut problem. Flexloc Locknut Division, STANDARD PRESSED STEEL Co., Jenkintown 28, Pa.

It's easy to install a FLEXLOC clinch nut

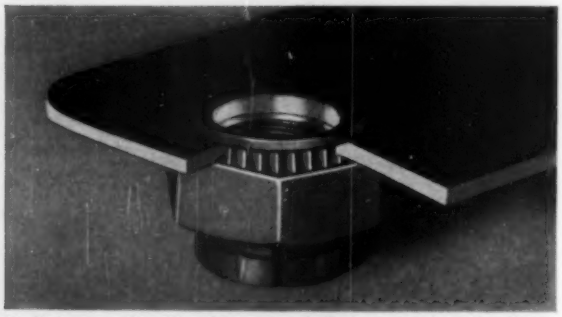


1. Hole in your subassembly accommodates the knurled shank of the FLEXLOC. The holding fixture is fitted with an inexpensive FLEXLOC dolly tip.

2. Fit the knurled shank of the nut into the hole. Your production engineer can easily design fixtures to make this operation completely automatic.



3. Clinch the shank to the subassembly with a single stroke. This electric press is equipped with a FLEXLOC punch tip which also can be used with an ordinary hammer.



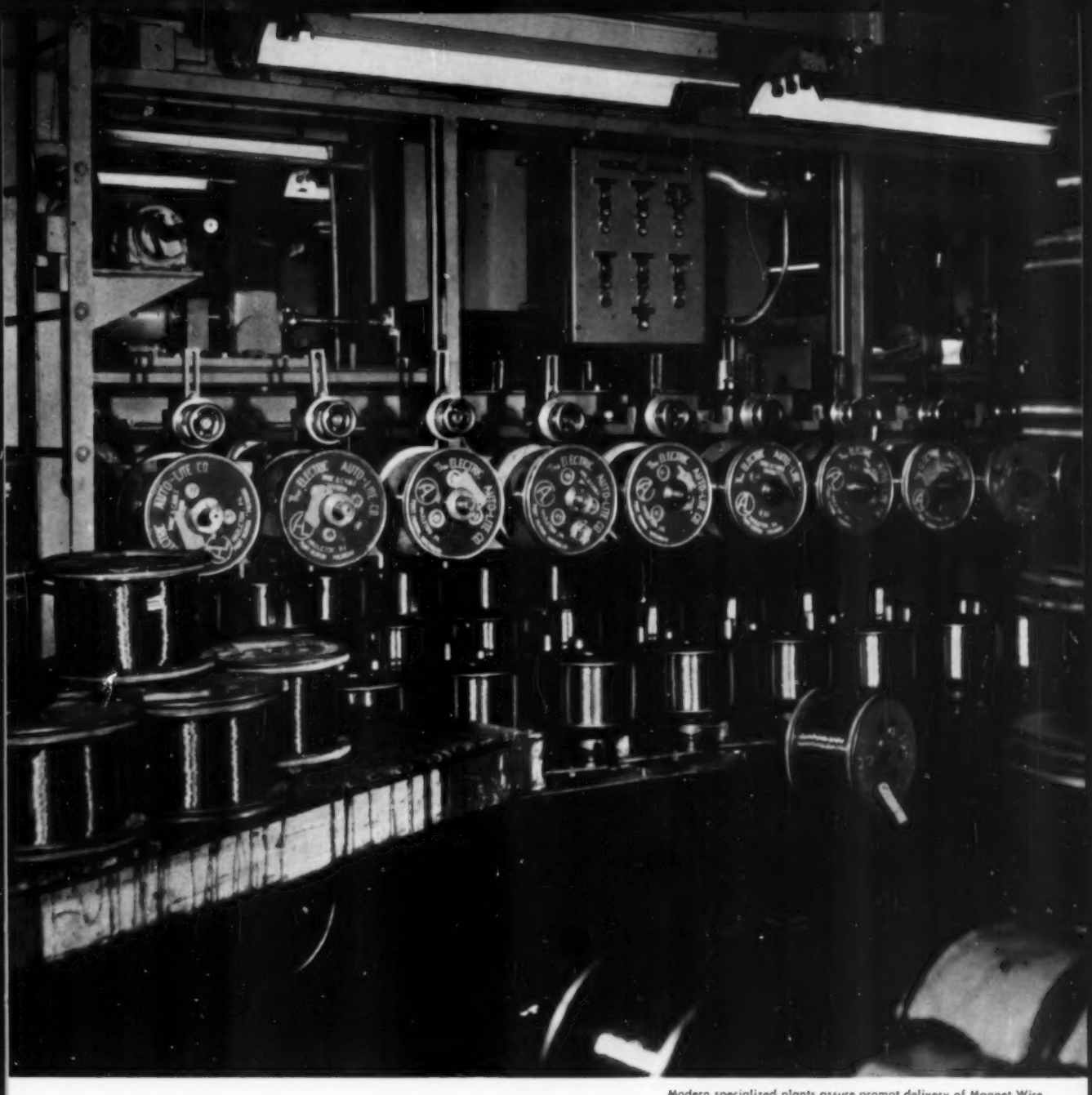
4. Cutaway view to show completed assembly. The clinch nut is now an integral part of it. The FLEXLOC functions as a tapped hole—one that will lock a screw securely in place.

FLEXLOC locknuts are sold through authorized industrial distributors

STANDARD PRESSED STEEL CO.

FLEXLOC LOCKNUT DIVISION SPS

JENKINTOWN PENNSYLVANIA



Modern specialized plants assure prompt delivery of Magnet Wire.

Auto-Lite Expands Productive Capacity to Assure Quick Delivery of Finest Quality Magnet Wire

New facilities including filtered air conditioning, latest equipment, and rigid production controls have been installed in Auto-Lite Wire Plants to give customers a new high in production, quality, and service.

MAGNET WIRE

PLANTS and WAREHOUSES . . .

Port Huron, Mich. YUkon 5-6131 • Hazleton, Pa. GLadstone 5-4781 • Yonkers, N. Y. Murray Hill 9-1842 • Chicago, Ill. WEbster 9-3144 • Cincinnati, O. POplar 1-3600

LECTALITE

Newest Enameled Magnet Wire by Auto-Lite!

LectALite magnet wire has been tested in accordance with AIEE 57 and MIL-W-19583 thermal aging test and found to be acceptable for Class B applications. LectALite can be applied to copper, aluminum, steel or silver magnet wires. Ideal for small electric motors, transformers, and TV yoke coils. Extreme resistance to Freon 12 and 22 and low extractables make it an outstanding wire insulation for hermetic refrigeration motors.

LectALite opens new magnet wire fields throughout the electrical industry.

This new insulation offers more heat resistance, higher thermoplastic flow, higher dielectric strength, greater flexibility and lower extractables than vinyl acetal insulation—with no increase in cost! Now available in sizes from 13 AWG through 30 AWG.

Tests indicate LectALite is the superior insulation for use in hermetic refrigeration motors due to its outstanding Freon 12 and 22 resistance plus low extractables. LectALite insulation has been found to have 30°C margin over vinyl acetal insulation by test performed under AIEE No. 57, Oct. 1955, "Proposed Test Procedure for Evaluation of the Thermal Stability of Enameled Wires" and MIL-W-19583 (NAVY) "Military Specification Wire, Electrical, Magnet, High Temperature, Film Insulated", July 15, 1955. Impregnation of LectALite wound coils can be done by any phenolic-alkyd type or suitable temperature rated impregnation varnishes.

The Auto-Lite magnet wire line is complete in classes O, A, B, and H to meet your design requirements.

ELECTRICAL, PHYSICAL AND CHEMICAL PROPERTIES

Description of Test	LectALite Insulation	Vinyl Acetal Insulation
Build	.0021	.0023
Heat Aging—hrs. 125°C	1500 hrs.	288 hrs.
Heat Aging Twist AIEE 200°C	506 hrs.	165 hrs.
Heat Aging Twist AIEE 225°C	110 hrs.	59 hrs.
Heat Aging Twist AIEE 250°C	20 hrs.	17 hrs.
Dry Dielectric Breakdown—KV/mil	2.5 to 3.5 KV/mil	1.5-2.0 KV/mil
Wet Dielectric Breakdown—KV/mil	1.1 KV/mil	1.1 KV /mil
Wet Insulation Resistance	1-2 months	1-3 weeks
G.E. Scrape Abrasion	45	41
Cut-Through Temperature—°C	300-320°	170-180°C
Heat Shock	(IX at 175°C 1 hr. O.K.	(IX at 125°C 1 hr. O.K.
Solderability	Good—900°F	Very Poor
Extractables—%	0.5-2.5%	3.0-6.0%
Solvent Resistance	Good	Good
Freon 22 Resistance	Excellent	Fails
Freon 12 Resistance	Excellent	Fair
Chemical Resistance 5% Sulfuric Acid	Very Good	Very Good
5% Hydrochloric Acid	Very Good	Very Good
1% Potassium Hydroxide	Very Good	Very Good
Xylene	Very Good	Very Good
Cresylic Acid	Good	Poor
Carbon Tetrachloride	Very Good	Very Good
Naphtha	Very Good	Very Good
Acetone	Poor	Poor
Alcohol	Very Good	Fair
Pyridine	Failed (Softens)	Failed (Softens)
Solvent Crazing (Stretched 5%—Dipped in Toluene)	Very Slight Crazing	Crazes
Annealed 15 Min. at 105°C Dipped in Toluene	No Crazing	Borderline Failure
Crazed Sample Heated 10 Min. at 150°C	Heals Completely	Heals Completely
Adherence Twist Test—4 in sample twisted on its own axis until coating twist cracks	120 to wire break	57

Auto-Lite Magnet Wire Line Is Complete In All Classes

CLASS O (90°C)

COTTON—Unbleached, long-staple white cotton protects primary insulation from damage caused by sharp bends and mechanical handling. Even wrapping forms a close, firm, continuous covering for increased dielectric. Additional layers, when required, are wound in opposite directions. When impregnated or immersed in a liquid dielectric, cotton is Class A insulation; when used alone, it is Class O. Available with colored tracers for coding. Manufactured to latest NEMA specifications. Available in a variety of combinations with other insulations. Double or triple conductors, individually cotton or paper covered, formed into a unit by an over-all cotton or paper covering supplied to meet requirements.

PAPER—A thin paper ribbon, wrapped spirally with overlap, is bonded to wire with adhesive. When impregnated or immersed in a liquid dielectric, paper is Class A insulation; when used alone, it is Class O. Similar to cotton in protective qualities, occupies less space because of uniformity of size, and increases dielectric. Paper insulation is available with one cotton wrap applied over two wraps of paper wound in opposite directions. Available with wax coating. Manufactured with multiple or single paper with a ¾ " lap, on round, square, or rectangular wire to the latest NEMA specifications.

Availability: **Round,** AWG #4 through #26;
Square, AWG #4 through #12;
Rectangular, width plus thickness not to exceed 0.650".

CLASS A (105°C)

COTTON—When impregnated or immersed in a liquid dielectric, cotton is Class A insulation.

PAPER—When impregnated or immersed in a liquid dielectric, paper is Class A insulation.

CONVENTIONAL ENAMEL—A smooth uniform insulation with the basic electrical, physical and chemical properties for limited use as Class A insulation. Manufactured in single and heavy grades to latest NEMA specifications.

Availability: **Round,** AWG #9 through #40.

FORMVAR—A synthetic insulation of vinyl acetal, Formvar has better dielectric qualities, higher heat resistance, better flexibility and adherence, lower power factor and better solvent resistance than conventional enamel. Formvar is manufactured in single and heavy grades to the latest NEMA specifications.

Availability: **Round,** AWG #4 through #40;
Square, AWG #4 through #12;
Rectangular, width plus thickness not to exceed 0.650".

NyALite—Moisture resisting quality of a Formvar base coat is coupled with an overcoating of nylon, for its excellent craze resistance, to produce NyALite. The high dielectric qualities of each insulation combine to provide an excellent magnet wire both in single and heavy grades for winding difficult coils.

Availability: **Round,** AWG #8 through #40.

BondALite—A combination of a Formvar insulation plus a thermoplastic overcoat. BondALite can be quickly and easily bonded wire-to-wire without damaging basic insulation. BondALite can be bonded in three ways: oven heat, electrical resistance, and solvents. Ease of bonding simplifies manufacturing of coils of the most complex forms.

BondALite No. 1 consists of Single Formvar with the addition of a bond coating to bring it up to the approximate dimension of Heavy Formvar.

BondALite No. 2 consists of Heavy Formvar with a bond coating to bring it up to the approximate dimensions of Triple Formvar.

BondALite No. 3 consists of Triple Formvar with a bond coating to bring it up to the approximate dimensions of Quadruple Formvar.

Availability: AWG #20 to #30.

SodALite—A new polyurethane insulation designed for ease of solderability at low temperatures (650-700°F) without scratch brushing or chemical stripping. SodALite has excellent over-all electrical and physical properties, approaching vinyl acetal insulation. It is manufactured under exacting conditions for ease of solderability.

Availability: AWG #8 through #40.

CLASS B (125° C)

LectALite—(*See page 2*)

IsALite—A new high temperature magnet wire for use up to 150° C as tested by Underwriter's Laboratories and Auto-Lite tests performed under AIEE No. 57. This magnet wire is manufactured with a polyester type enamel (Isonel) and found to have outstanding physical, electrical and chemical properties.

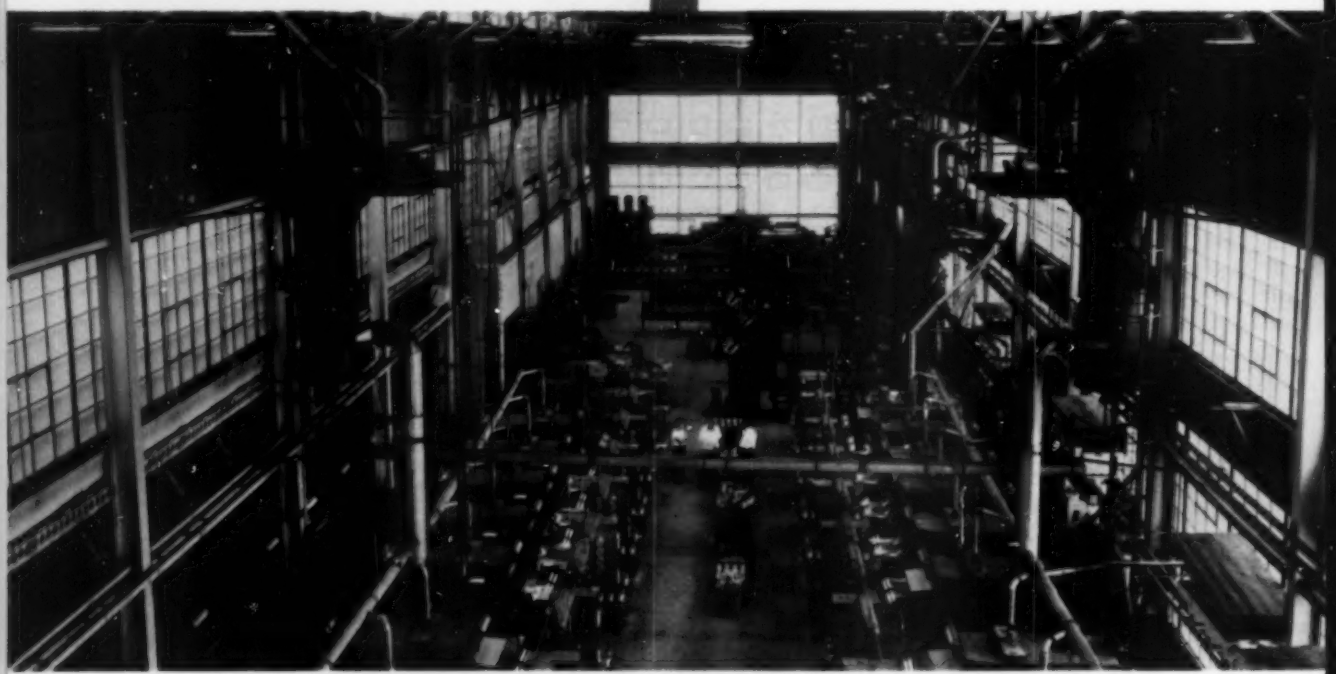
Availability: **Round,** AWG #8 through #40.

CLASS H (180°C)

GLASS-DACRON—An inorganic insulation bonded with suitable organic-inorganic binders for use at Class H ratings. Good electrical and mechanical properties are incorporated in this product to give improved flexibility and abrasion. It is wrapped in an even spiral, forming close, firm, continuous covering with single or double glass-dacron for increased dielectric strength.

Availability: **Round,** AWG #4 through #26; **Square,** AWG #4 through #12; **Rectangular,** width plus thickness not to exceed 0.650".

Latest equipment and controls assure consistent quality.



SEND FOR THESE FREE WIRE AIDS . . .

WIRE-O-METER—This convenient slide-rule type of pocket reference gives you complete specifications on all common sizes of wire. At a glance it tells you area in circumference, feet to a pound and pounds per thousand feet, turns per lineal inch and per square inch, and ohms per foot and ohms per pound.

MAGNET WIRE CATALOG—This quick reference is full of facts covering many different types of wire. It's complete with physical, chemical, electrical and military specifications.

AIRCRAFT WIRE AND CABLE KIT—This handy kit gives you complete military specifications for Auto-Lite Aircraft Wire including samples of famous Auto-Lite 350 General Purpose High Temperature Aircraft Wire.

WIRE GUIDE OF ELECTRICAL AND CHEMICAL PROPERTIES—Here's a handy reference that gives you a complete run-down on 9 basic kinds of insulation.

MAIL TODAY

THE ELECTRIC AUTO-LITE COMPANY
WIRE AND CABLE DIVISION
PORT HURON, MICHIGAN

☐ MAGNET WIRE CATALOG ☐ WIRE-O-METER
☐ AIRCRAFT WIRE AND CABLE KIT
☐ WIRE GUIDE OF ELECTRICAL & CHEMICAL PROPERTIES

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NOTHING *can equal Stainless Steel*

in its unique combination of properties

No other design material can match Stainless Steel in its unique combination of desirable properties: corrosion resistance, strength, hardness, beauty, cleanability and easy fabrication. If you're looking for a reliable source of supply, remember that United States Steel offers you the widest range of types, finishes and sizes.

UNITED STATES STEEL CORPORATION, PITTSBURGH
AMERICAN STEEL & WIRE DIVISION, CLEVELAND
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
NATIONAL TUBE DIVISION, PITTSBURGH
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USS STAINLESS STEEL

SHEETS · STRIP · PLATES · BARS · BILLETS
PIPE · TUBES · WIRE · SPECIAL SECTIONS

UNITED STATES STEEL

USS

For Formability...

Jet engine and pressure vessel makers are using roll-formed rings in large numbers these days. Alloy Manufacturing Company in Pittsburgh is a major supplier of Stainless Steel fabricated parts, and they process this steel on ordinary "carbon steel rated" equipment without difficulty.

For Cleanliness...

Bates Manufacturing Company, Lewiston, Maine, is a famous name in cotton goods. They used to have trouble with dyeing equipment; the iron vats held the old colors and "killed" new colors. With Stainless Steel dye kettles, old colors actually *rinse* out, without costly scrubbing.

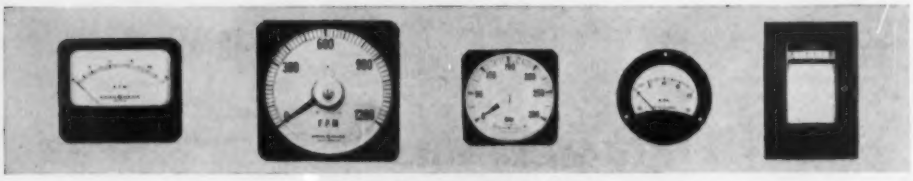
For Style...

G & G Woodcraft, Dinette Division, in Detroit, is selling a handsome new dinette table, designed by Gelitis, with a polished Stainless Steel top. The top is backed with plywood, and there is no metallic sound when it is struck. Stainless is a perfect material for contemporary design, and it's so *practical*.

General Electric Speed Measuring Systems:

Handsome Appearance and Top Quality Increase Customer Acceptance and Resale Value

G-E application engineering and fast shipment help you get the right system when you need it



COMPLETE LINE of indicators and recorders to choose from offers you the exact type speed measurement you require.

General Electric speed measuring systems are offered in a complete line for every application; each system you buy is *tailor-made* to meet your requirements.

Here are 9 reasons why you get optimum performance for your investment with G-E speed measuring systems:

1. Handsome appearance of G-E indicators contributes to the good looks of your product and increases salability.

2. Top quality of every instrument assures you of extreme reliability under severe conditions.

3. High accuracy of ±1% of full scale is made possible by factory calibration of generator and indicator together.

4. Small size of both generators and indicators gives you greater latitude when selecting a mounting position.

5. Excellent readability of indicators is provided by long scales and large numbers. Non-parallax glass of DB-16 and DB-18 indicators allows reading from almost any angle.

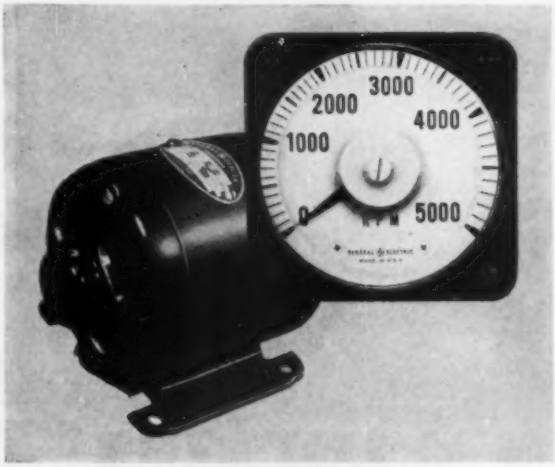
6. Totally enclosed, both generators and indicators are fully protected from dust and dirt. Explosion-proof enclosures are available on some models.

7. Fast shipment of complete systems helps you meet commitments.

8. G-E application engineering is available to you on request to help you solve your speed measuring problems and select the proper equipment.

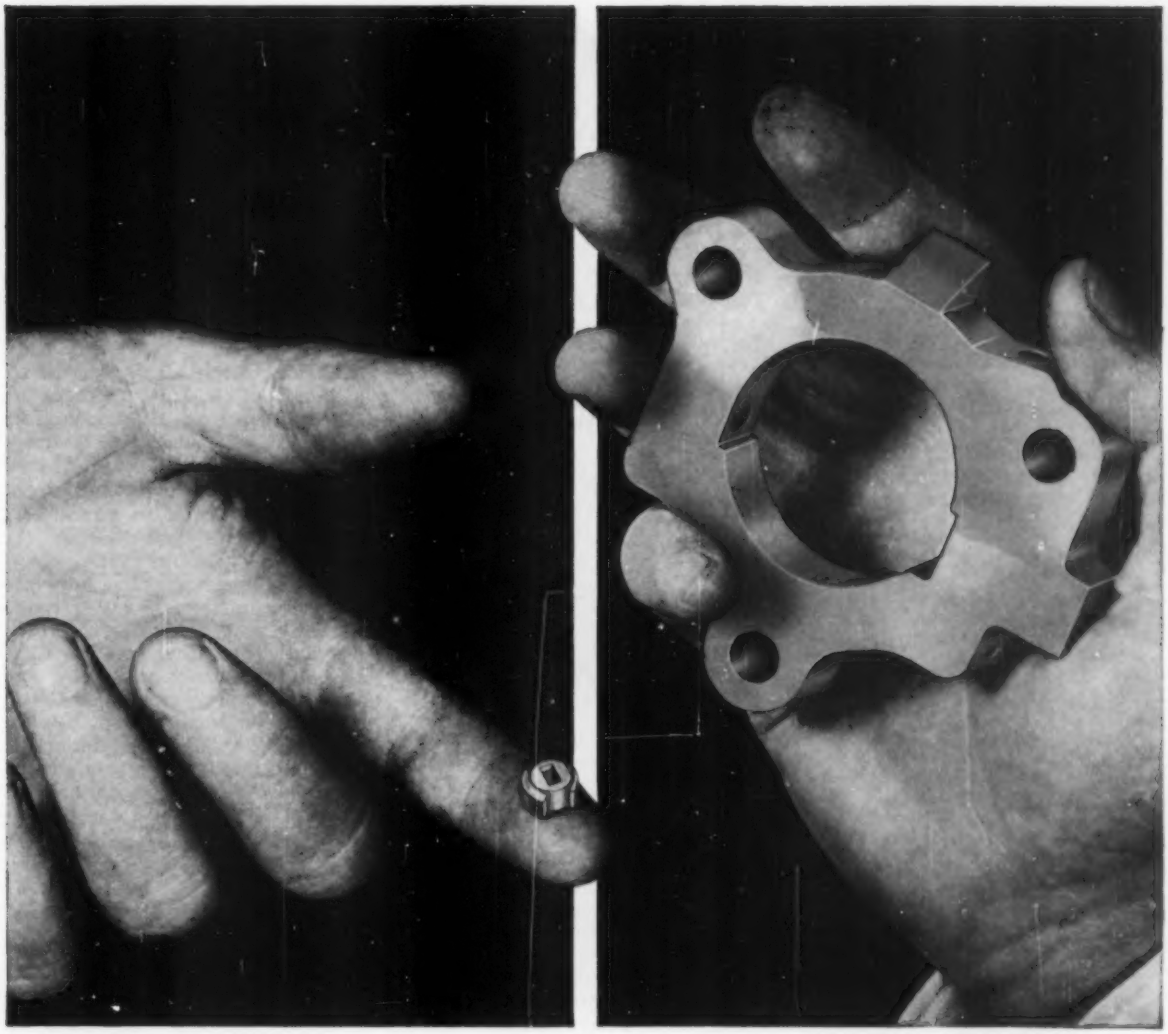
9. Any legend you require will be marked on your G-E tachometer indicator scales. Your instruments may be calibrated in units such as feet per minute, inches per minute, spindle rpm or any related speed. Manufacturer's or customer's name may also be imprinted on the scale face.

If you would like additional information on General Electric's complete line of speed measuring systems, call your nearest General Electric Apparatus Sales Office or write for Bulletins GEC-1258 and GEA-6427 to Section 585-57, General Electric Company, Schenectady 5, New York.



EXCEPTIONAL ACCURACY is made possible because generator and indicator are calibrated as a unit at the factory.

GENERAL ELECTRIC



Does part *size* limit use of metal powder?

Everything has limits. But the illustrations above will give you some idea of the wide range of part sizes easily produced from metal powder.

Often a single press operation will replace many machining operations, yet the finished part comes off the line more accurately made in every detail.

Moraine Products has the experience gained from the production of hundreds of millions of metal powder parts in an infinite variety of shapes and sizes. This experience and our familiarity with other types of metal working processes, guide our engineers in determining whether our materials and our processes are best suited to the production of a specific part.

When we accept a job to make metal powder parts, it is only after thorough study has shown that the customer will receive parts of the highest uniform quality for dependable end-product performance. Of course, on-time delivery is assured, regardless of quantity.

Moraine Products also produces: Moraine Power Brakes—Delco hydraulic brake fluids, brake assemblies, master cylinders, wheel cylinders, and parts—Moraine friction materials—Moraine-400 and M-100 automotive engine bearings—self-lubricating bearings and porous metal filters—rolled bronze and bi-metal bushings.

Another General Motors Value

Moraine Products
Division of General Motors, Dayton, Ohio

Know your timer types...

Grouping the multiplicity of timer types into four broad classes simplifies equipment designer's job:

INTERVAL TIMERS

The first—and simplest—group is that of the interval timers. These consist basically of a motor, an arm or cam, and a switch. To operate the timer, the user simply sets the mechanism manually to the desired time interval. This action transfers switch contacts that start the timer motor.

The motor drives the timer mechanism to the end of the timing cycle. At this point the switch returns to its original position and the motor shuts off.

A variety of dials, knobs, push-

INTERVAL TIMER of advanced design, the new Cramer Type 241 features large easy-to-read dial, pushbutton start, automatic and immediate reset and repeat accuracy of ± ¼ of 1% of full scale. Bulletin PB-241.

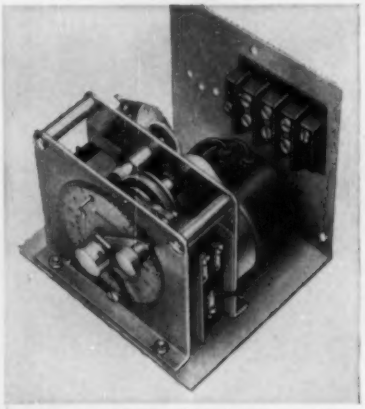
button start, automatic reset features, special housings and additional load switches may be used, but the basic operation is the same. Interval timers are used in applications that require frequent changes in setting—like photographic exposure timing.

TIME DELAY RELAYS

The time delay relay represents the second large group of timing devices. These units provide accurately timed delays between the closing of an external remote switch and the transfer of a load switch. At the end of each cycle, the motor shuts off automatically, and the standard device remains in this "timed out" condition until the clutch is released allowing the timer to reset. Other variations reset automatically at the end of a cycle. Models are available to either reset on power failure or suspend operation until the circuit is restored.

Special housings, additional switches, various clutching mechanisms, and a wide selection of wiring arrangements make the time delay relay an extremely versatile device.

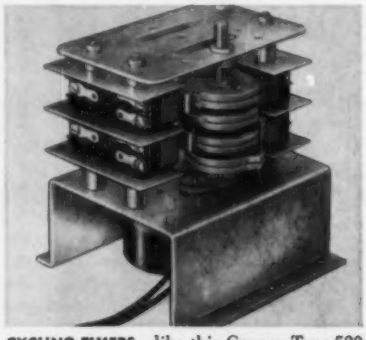
A typical application is for regulating processes such as heat treating where the timer controls the amount of time required to produce the desired change in the metal.



TIME DELAY RELAYS—like the Cramer Type 440A above—are rugged, dependable and accurate devices to control from 1 to 5 load circuits. For flush, surface or panel mounting. Bulletins PB-310 and PB-311.

CYCLING TIMERS

In the third category are found the cycling timers. Fundamentally these units are made up of the driving motor, a cam (or arm) which is revolved continually by the motor, and a switch operated by the cam. The cycling timer produces switch transfer repeatedly, according to the cam cuts, as long as the motor runs.



CYCLING TIMERS—like this Cramer Type 520 come in 1 to 8 poles. Normally factory preset for highest accuracy. Operating speeds 1 rev./6 sec. to 1 rev./day. Bulletin PB-510A.

Variations of the cycle timer include changing the motor speed, cutting cams in an almost infinite number of combinations, and adding switches. The cam setting may be fixed or adjustable. Special housings are available. Cycle timers are used to control a program or sequence of events as in a signaling system.

TIME TOTALIZERS

Time totalizers, or elapsed time indicators, range in complexity from a simple motor-driven counter to the precision time totalizer used in scientific research. The former, usually used as a running time meter, counts discrete time *units* from tenths of a second to hours. The more elaborate time totalizer is actually an electrical stop clock capable of measuring time intervals to an accuracy of ± 0.01 second. Running time meters are used to record the operating or down time of industrial machines. They are offered in many models—with or without reset, in portable or die-cast enclosures, etc. Time totalizers are commonly applied in test equipment for industrial and military laboratories.

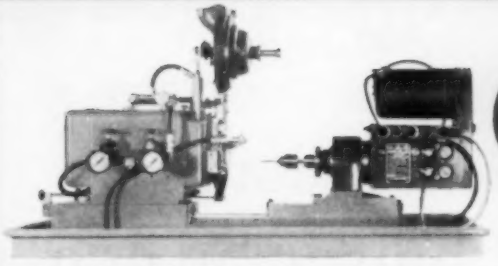
TIME TOTALIZER of laboratory quality. The Cramer Type 690 features easy-to-read scale and pointers for fast, exact readings, accuracy to ± 0.01 second. Reset lever conveniently located on dial face. Bulletin PB-610.

LEARN MORE about these four basic timer types from Cramer's complete line. Just ask us to send you our bulletins on the types that interest you. Nearly 100 varieties are *stocked* for immediate shipment. Cramer Controls Corporation, Box 7, Centerbrook, Connecticut. (Formerly R.W. Cramer Co.) 7.1

TALK IT OVER WITH

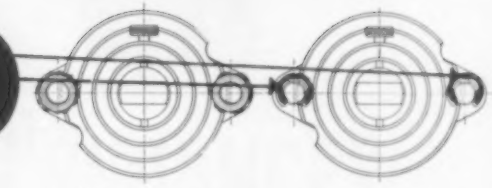
CRAMER CONTROLS
CORPORATION

Waldes Truarc Retaining Rings Eliminate Machining and Parts—Cut Assembly Time on Drill and Tapper



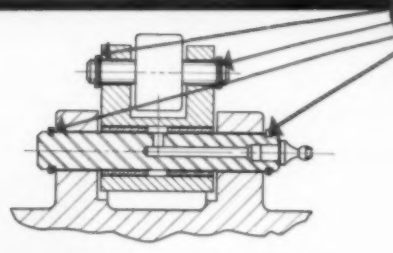
Beco Model 410 Drill and Tapper

The Batchelder Engineering Co., Inc., Springfield, Vermont uses 4 different sizes of 2 different type Waldes Truarc rings in their new BECO Model 410 Automatic Drill and Tapper. Truarc rings speed assembly, reduce machining, improve design.



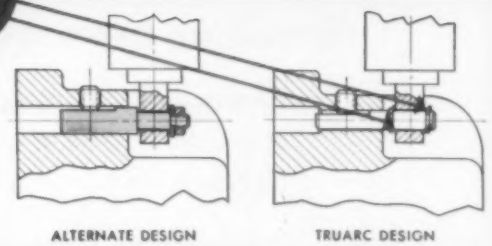
Clamp Cylinder Rod Stop Assembly

Truarc "E" Rings (Series 5133) replace stop nuts in the Clamp Cylinder assembly. They eliminate need for threading 2 rods ...the danger of cross-threading nuts...and costly rejects. Truarc Rings cut assembly time and cost.



Bell Crank Pivot Assembly

Truarc Rings (Series 5100) in Bell Crank Pivot assembly permit grease hole not possible with cotter pin fastener. Use of nuts would have increased machining and assembly costs considerably.



Hopper Cylinder Anchor Pin Assembly

2 Truarc Rings (Series 5100) secure and position end of vertical air cylinder. Rings eliminate extra cost of machining 3-diameter pin, threading and undercutting...plus nut and washer. Assembly is quick and sure.

Whatever you make, there's a Waldes Truarc Retaining Ring designed to improve your product... to save you material, machining and labor costs. They're quick and easy to assemble and disassemble, and they do a better job of holding parts together. Truarc rings are precision engineered and precision made, quality controlled from raw material to finished ring.

36 functionally different types... as many as 97 different sizes within a type... 5 metal specifications and 14 different finishes. Truarc rings are available from 90 stocking points throughout the U. S. A. and Canada.

More than 30 engineering-minded factory representatives and 700 field men are available to you on call. Send us your blueprints today... let our Truarc engineers help you solve design, assembly and production problems... without obligation.

For precision internal grooving and undercutting... Waldes Truarc Grooving Tool!

WALDES

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RETAINING RINGS

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47-16 AUSTEL PLACE, L. I. C. 1, N. Y.

Waldes Kohinoor, Inc., 47-16 Austel Place, L. I. C. 1, N.Y.
Please send the new supplement No. 1 which brings Truarc Catalog RR 9-52 up to date.
(Please print)

Name _____

Title _____

Company _____

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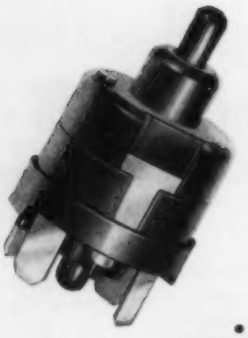
PN019

WALDES TRUARC Retaining Rings, Grooving Tools, Pliers, Applicators and Dispensers are protected by one or more of the following U. S. Patents: 2,382,948; 2,411,426; 2,411,761; 2,416,852; 2,420,921; 2,428,341; 2,439,785; 2,441,846; 2,455,165; 2,483,379; 2,483,380; 2,483,383; 2,487,802; 2,487,803; 2,491,306; 2,491,310; 2,509,081; 2,544,631; 2,546,616; 2,547,263; 2,558,704; 2,574,034; 2,577,319; 2,595,787, and other U. S. Patents pending. Equal patent protection established in foreign countries



Big Ratings
Small Price
Unlimited Uses

—with the Mallory Miniature Plunger Switch

POSSIBLE USES

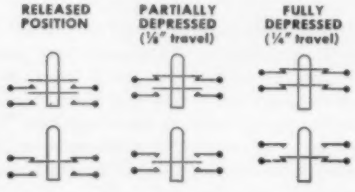
Operate it by cam, door, button, slide or index. Use it singly—or gang them for sequence. Pick a sequence contact combination for your problem.

THE SPECIFICATIONS

15 Amps.....240 volts AC
20 Amps.....120 volts AC
1½ H.P.....240 volts AC
¾ H.P.....120 volts AC
¼" x ½2" (thick) spades
.441" single mounting hole required
1½2" maximum diameter
¼" plunger travel

CIRCUIT COMBINATIONS

These are only two of the many possible circuit combinations of the plunger switch.



No stop at intermediate position. Spring returns plunger to released position.

For complete literature and prices, write or call Mallory—today.

Serving Industry with These Products:
Electromechanical—Resistors • Switches • Television Tuners • Vibrators
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ANNOUNCES

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NEW Norgren Air Line Filters

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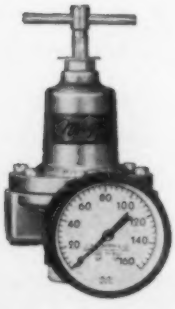


NEW Norgren Pressure Regulators

- **GREATER ACCURACY OF REGULATED PRESSURE** — balanced valve and increased effective diaphragm area provide improved accuracy over a wide operating range.
- **RELIEVING OR NON-RELIEVING TYPE AVAILABLE**
- **IMPROVED RELIEVING CHARACTERISTICS** — automatic relief of excess pressure. Holds system pressure close to regulator setting.

For complete information...

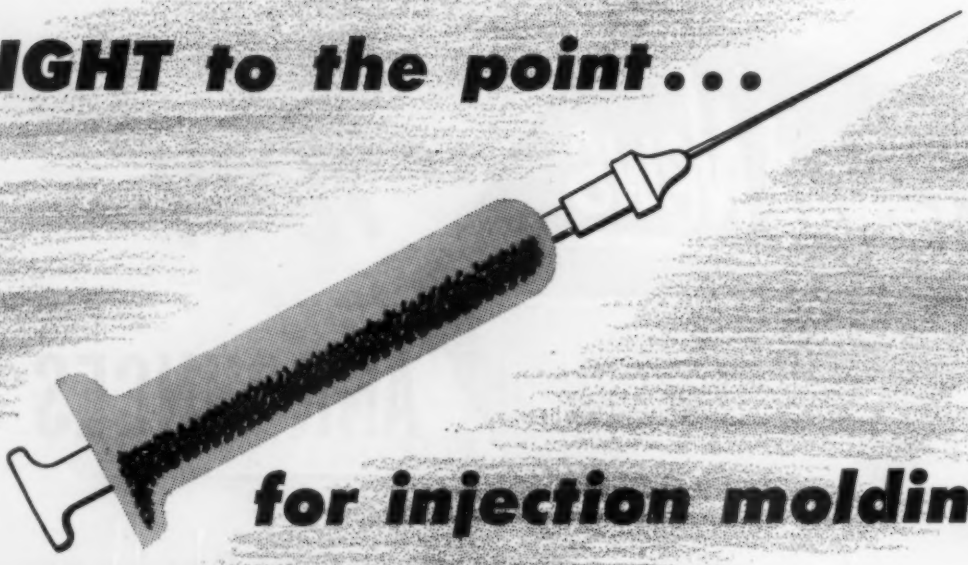
call your nearby Norgren Representative listed in your telephone directory—or

WRITE THE FACTORY FOR NEW CATALOG.

C. A. NORGREN CO.

3428 SOUTH ELATI STREET • ENGLEWOOD, COLORADO

RIGHT to the point...



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THE PERFECT RESIN FOR THE MANUFACTURE OF ANY PRODUCT THAT DEMANDS . . .

- Chemical Resistance
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Injection Molding . . . Extrusion . . . Calendering . . It's CYCOLAC for any or all Three Methods

Injection molded items for high gloss, dimensional stability; extruded items for high production of sheet, pipe, or profiles; calendered sheet stock for post-forming operations. All products characterized by high impact resistance, bright colors, chemical resistance, low brittle point, low creep and excellent electrical properties.

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MARBON CHEMICAL . . . ***Precision Resins for Precision Made Products***

PRECISION WASHERS

For automatic transmissions and similar bearing applications

FEDERAL Mogul

Solid steel or bronze; steel faced with babbitt or copper-lead, or copper-lead on *both faces*. Flat, spherical or special shapes. Grooves, holes, nibs, scallops or lugs. O.D. 1″ to 6″. Wall thickness: solid, .028″ to .141″; bimetal, .034″ to .141″. Cold rolled for heavy-duty. Large capacity. Complete engineering service.

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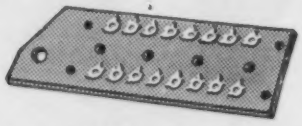
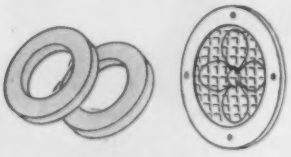
RESEARCH • DESIGN • METALLURGY • PRECISION MANUFACTURING

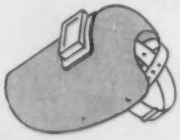
Tips for designers



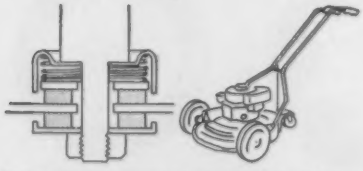
Terminal board for a complex circuit in an electronic spectrophotometer instrument is made of Taylor Grade LE laminate . . . selected for its insulating and mechanical properties.



Large exhaust fans use Taylor paper base phenolic washers to help absorb thrust . . . an inexpensive arrangement, with long life.



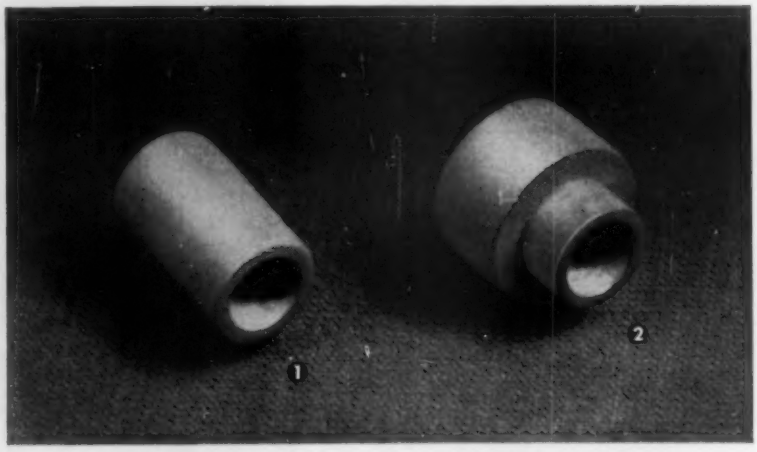
Welders' helmets are fabricated from tough, durable Taylor vulcanized fibre . . . readily formed to many desired contours.



Rotary lawn mower utilizes abrasion resistance of Taylor phenolic laminate washer in slip-clutch attachment of drive shaft to cutting blade.

TAYLOR FABRICATING FACILITIES

Your production problems can often be simplified . . . schedules safeguarded . . . inventory headaches cured . . . and overall costs reduced by having Taylor fabricate finished parts of vulcanized fibre and laminates to your specifications. Efficient, modern facilities are ready to serve you. Write to Taylor about your specific requirements.



Chosen for its mechanical strength and electrical insulation, this Taylor laminated tubing provides an economical means for making (1) an ignition breaker arm bushing and (2) a distributor terminal bushing.

Strength plus electrical insulation, available in Taylor laminated tubing

Among the most versatile basic materials available to the designer, Taylor laminated plastics are constantly finding new applications . . . in new products for future markets and as replacements for parts in current production.

Widely used in flat sheets for the fabrication of parts for electrical components, Taylor laminates are also available in tube form. This makes them applicable to an even greater number of parts . . . such as bushings, guides, shafts, and housings for resistors, thermistors and fuses. The tubes are supplied with inside diameters as small as 1/32". Standard lengths are 36" or 49", depending on grade, inside diameter and wall thicknesses.

Included in the broad selection of Taylor laminated tubing are a great variety of different grades . . . paper, fabric and glass bases combined with special formulations of phenol, melamine, silicone and epoxy resins. Each grade offers electrical and physical properties which qualify it for a specific application at a reasonable price.

Of particular interest to economy-minded designers and production managers is the fact that this laminated tubing permits the use of a part for a mechanical application without the need for extra electrical insulation.

Plan to take greater advantage of Taylor laminates . . . in tube, sheet and rod form . . . either in your present products or in those which you are now designing. Call or write for a discussion of your specific requirements.

Designing a new wire product?

Call American Steel & Wire!

Steel wire comes in so many different grades, shapes and finishes that it isn't easy to keep them all at your fingertips.

For this reason, we suggest that you give your American Steel & Wire representative a chance to help with new designs while they are still on the drawing board. He may be able to suggest 1) a more economical wire, 2) a wire that will fabricate more easily or 3) a slight design change that will simplify production or lower the cost of the raw material.

At AS&W, we *use* a lot of wire in our own plants; and have learned many little tricks that are yours for the asking. Just call your American Steel & Wire representative.

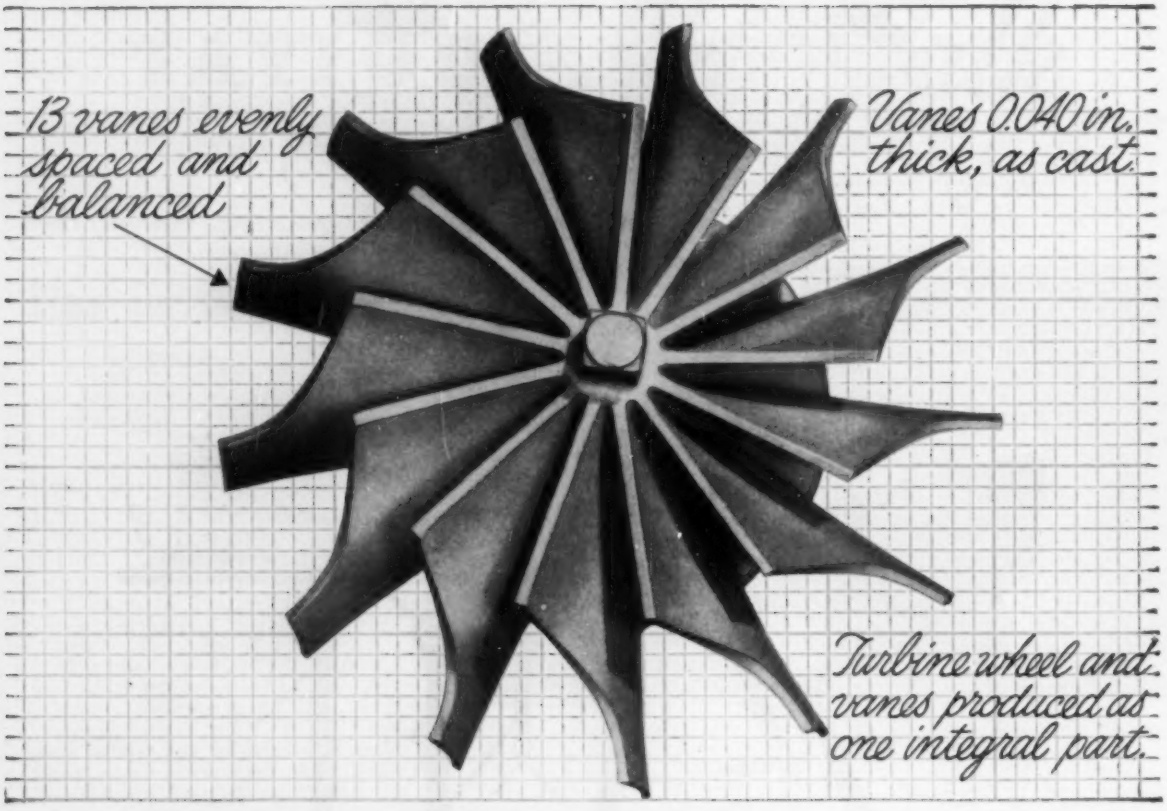
AMERICAN STEEL & WIRE DIVISION, UNITED STATES STEEL, GENERAL OFFICES: CLEVELAND, OHIO
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA., SOUTHERN DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS AMERICAN MANUFACTURERS WIRE

USS

AMERFINE—*high quality fine wire.*
AMERSPRING—*music steel spring wire.*
AMERTEMP—*heavy-duty oil-tempered wire.*
AMERLOY—*alloy heading wire.*
AMERHEAD—*uniform heading wire.*
AMERSTITCH—*extra-tough metal stitching wire.*

UNITED STATES STEEL



Tough Design Problem Solved by Investment Casting . . . .

The precision-investment-casting process proved to be the most practical and economical way to produce an efficient turbine wheel for a diesel engine supercharger. The wheel rotates at 42,000 rev. per min. and is exposed to a 1450-deg. F. temperature. It had to be made of a hard-to-machine alloy capable of standing up under these severe service conditions. Yet, to operate efficiently, the vanes of the wheel had to be extremely thin and formed to an intricate shape.

The vanes and wheel were produced as one integral part by HAYNES' precision-investment casting process. Only two simple finishing operations were needed to put the wheel in service. The vanes are only 0.040 in. thick . . . too thin to produce by other methods without a prohibitive amount of machining on a hard, tough alloy.

The successful production of this turbine wheel points up one of the big advantages of HAYNES' precision-investment casting process . . . the planning freedom it offers to design engineers. For the full story on how this modern mass-production method can help you, contact one of the District Sales Offices listed below.

HAYNES TRADE-MARK ALLOYS

HAYNES STELLITE COMPANY

A Division of Union Carbide and Carbon Corporation

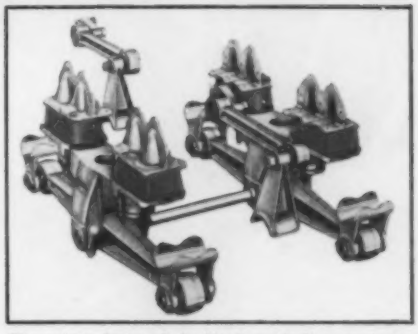
UCC

General Offices and Works: Kokomo, Indiana

Sales Offices

Chicago • Cleveland • Detroit • Houston • Los Angeles • New York • San Francisco • Tulsa

"Haynes" is a registered trade-mark of Union Carbide and Carbon Corporation.



The unique design of the "load cushion" accounts for smooth, even rides in the full range of loads, empty to full. Enjay Butyl Rubber (in red) made it possible.

ENJAY BUTYL "LOAD CUSHION"

replaces steel springs in big Tractor Trailers

The "load cushion" is an important innovation in tandem suspension. Developed by the Hendrickson Mfg. Company, it is made of Enjay Butyl and replaces steel leaf springs. Utilizing the great strength and impact resistance of Enjay Butyl, the "load cushion" gives the ultimate in a soft, easy ride within the complete range of loading, from empty to full. Besides giving a smoother, steadier ride, it increases tire mileage, reduces weight and significantly reduces wear and tear on equipment.

Enjay Butyl has proved to be the answer to problems in many fields of industry. It may well be able to cut costs and improve the performance of *your* product. Low-priced and immediately available, Enjay Butyl may be obtained in non-staining grades for white and light-colored applications. Get all the facts by contacting the Enjay Company. Complete laboratory facilities and technical assistance are at your service.

ENJAY BUTYL

Enjay Butyl is the super-durable rubber with *outstanding* resistance to aging • abrasion • tear • chipping • cracking • ozone and corona • chemicals • gases • heat • cold • sunlight • moisture.

ENJAY *Pioneer in Petrochemicals*

ENJAY COMPANY, INC., 15 West 51st Street, New York 19, N.Y.

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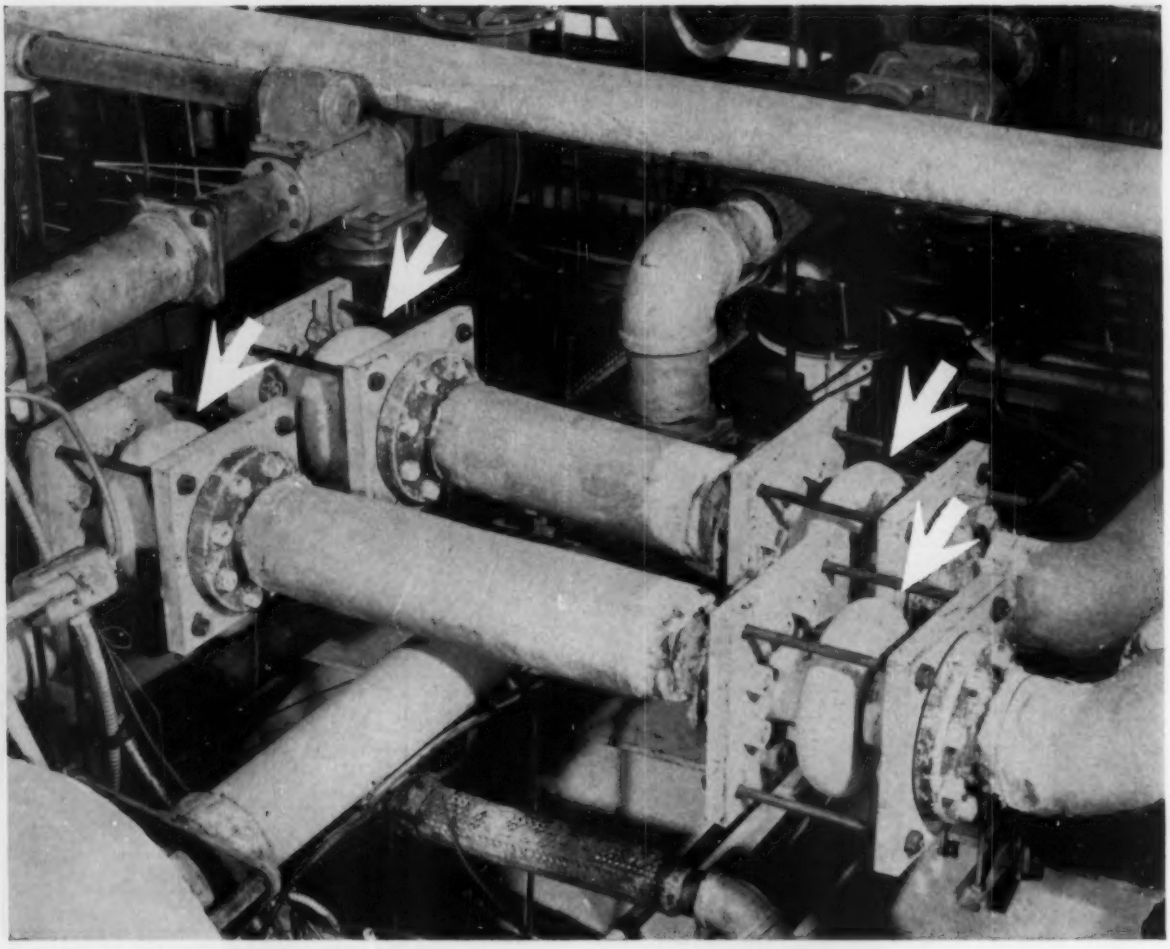


"Only *Carpenter* Stainless Tubing gives us failure-proof service"

The manufacturer of these four truly maintenance-free packless expansion joints (shown by arrows, above) has tried other stainless tubing, but says Carpenter Stainless Tubing is the "only one that renders failure-proof service".

These joints absorb thermal expansion, operating at pressures up to 210 psi and temperatures up to 650°F. They are typical of expansion joints made from Carpenter Tubing which operate at pressures up to 10,000 psi or temperatures as high as 1800°F. Once installed, they have never been replaced. Some have been in service over 15 years. The quality and uniformity of Carpenter Stainless Tubing contributed greatly to the trouble-free fabrication and maintenance-free service of these joints.

If an extra measure of quality in stainless tubing and pipe can improve your products or operation, call your Carpenter Distributor. He's your nearby source of better stainless tubing and pipe.

MEMBER

The Carpenter Steel Company, Alloy Tube Division, Union, N. J.

Export Dept.: The Carpenter Steel Co., Port Washington, N.Y.—"CARSTEELCO"

Carpenter

Stainless Tubing & Pipe

(Actual Size)
K3-SERIES

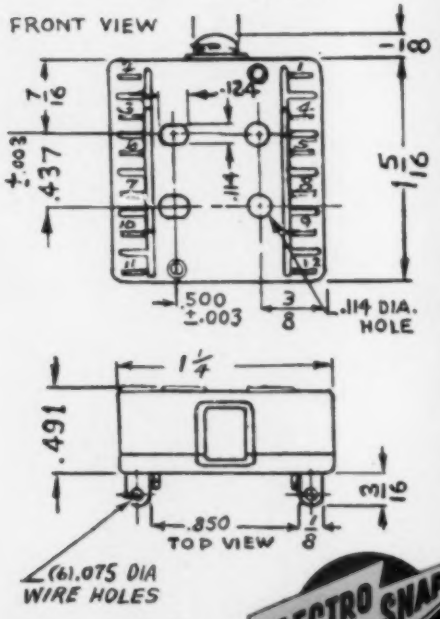
TRIPLE-POLE SWITCH

OPERATING CHARACTERISTICS

CONTACT ARRANGEMENTS:
K3-4—TRIPLE-POLE, DOUBLE THROW
K3-2—TRIPLE-POLE, NORMALLY OPEN
K3-1—TRIPLE-POLE, NORMALLY CLOSED

ELECTRICAL RATING:
15 AMP 125/250 V.A.C.
15 AMP 30 V.D.C. RESISTIVE
10 AMP 30 V.D.C. INDUCTIVE

PROBABLE MECH. LIFE.....1,000,000 OPS
PROBABLE ELEC. LIFE..... 500,000 OPS
AMBIENT TEMP. RANGE.....—100° TO +275° F.*
*(—100° to +375°F. available)



New ELECTRO SNAP SIMULTANEOUS

TRIPLE-POLE SWITCH

for interrupting 3-phase,
110 V, 400 cycle AC circuits

6-CIRCUIT CONTROL — in a small package.
Makes possible a wide variety of circuit combinations.

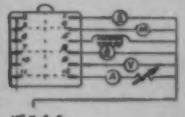
SIMULTANEOUS "MAKE & BREAK" ACTION
Permits unusual applications, reduces arcing, prolongs switch life and increases electrical capacity.

This completely new Electro-Snap triple-pole switch simultaneously reverses current flow through three windings of a 3-phase motor up to 1 H.P. and interrupts other types of multi-switching installations. Instantaneous snap-action of the three poles is independent of the speed of actuation — even extremely slow moving cams can be used.

The K3-Series offers designers a wide variety of 3-phase circuit hookups for servo-controls, to limit movement of machine members and as a start-and-stop switch which formerly were possible only with complicated relays or a number of separate switches. A large selection of standard actuators is available.

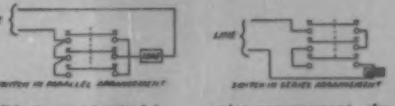
LOOK WHAT YOU CAN DO WITH IT!

Control Six Circuits with ONE Snap



Used in motor control device switch, when actuated, turns on the red light on No. 1, the solenoid on No. 5, the voltmeter on No. 9 and turns off the motor on No. 4, the green light on No. 8 and the furnace and ammeter on No. 12.

Wire Movable Poles in Series for High Voltage or in Parallel for High Current

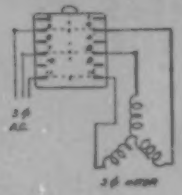


With the switch wired in parallel arrangement, the current is divided into 3 paths through the switch. This permits the switch to be used with a load rated up to 3 times the ampere rating of the switch.

With the switch wired in series arrangement, the current has only 1 path through the switch. The multiple breaks in the current path permits the switch to be used where the line voltage is rated up to 3 times the voltage rating of the switch; ampere rating not affected.

Start and Stop Three-Phase Motors

Completely disconnect all current supplied to a 3-phase motor by interrupting 3 phases simultaneously with one snap.

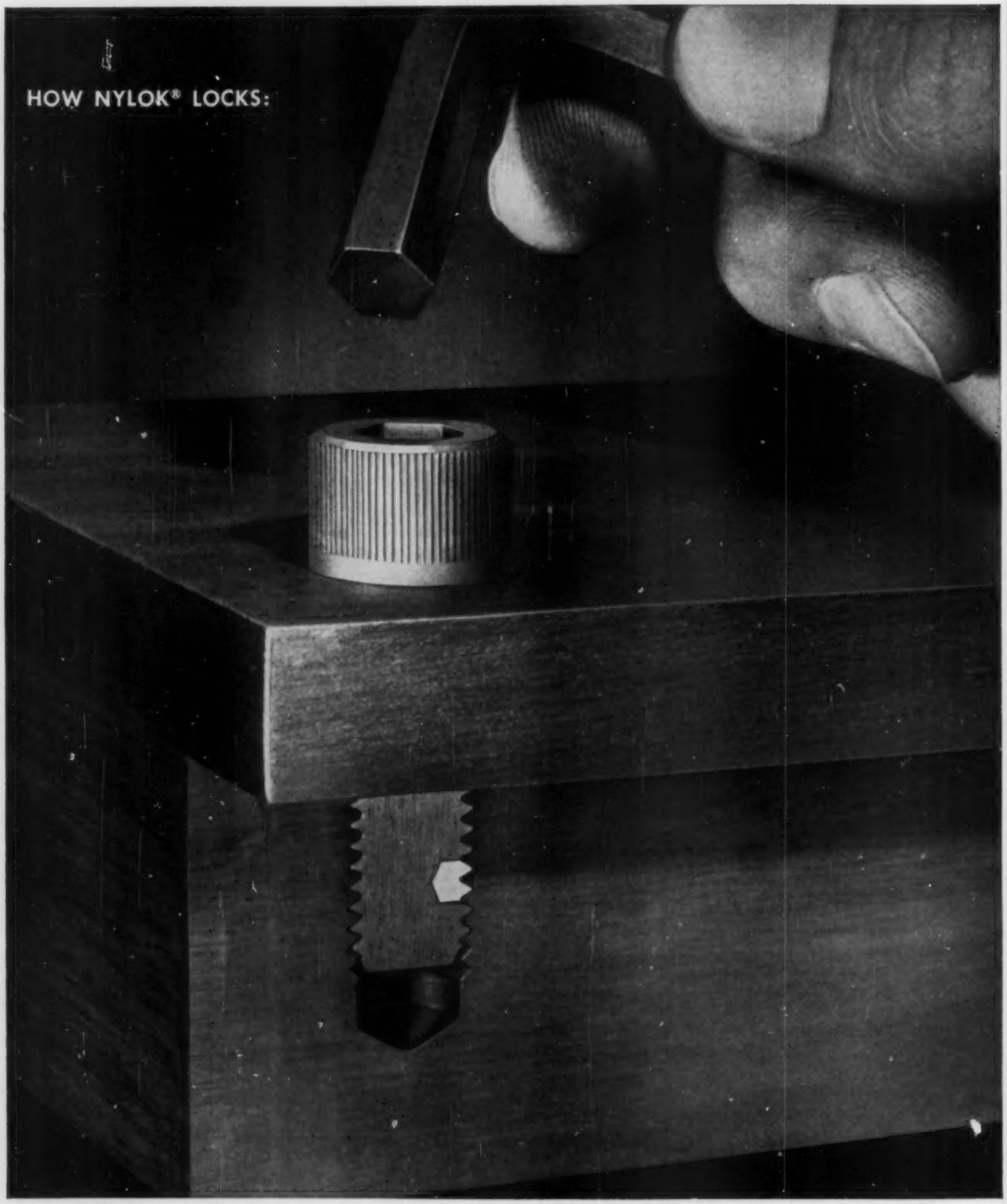


ELECTRO-SNAP
SWITCH AND MFG. CO.
4246 West Lake Street • Chicago 24, Illinois

ELECTRO SNAP

MODERN DESIGN
IN A COMPLETE LINE
OF SWITCHES

NEW—self-locking UNBRAKO



LOCKED! The tough, resilient nylon pellet keys itself into the mating threads. It forces threads together and locks the screw securely.

socket head cap screws

Self-locking UNBRAKO socket head cap screw.

BEFORE ASSEMBLY. The nylon pellet projects slightly. When assembled, threads will be impressed into it.

AFTER REMOVAL. "Plastic memory" of pellet has expanded impressed threads to greater diameter than screw threads. Screw can be used repeatedly. In use, "memory" keeps threads tightly locked.

They won't work loose. And they simplify design and save production time.

UNBRAKO socket head cap screws are now available embodying the Nylok* self-locking principle. Nylok provides the first truly practical solution to the problem of making cap screws self-locking.

An UNBRAKO cap screw with Nylok is a single self-locking unit. No auxiliary locking devices are needed. Just thread the UNBRAKO into any tapped hole. *Seated or not*, it locks positively wherever wrenching stops. The tough, resilient nylon pellet forces mating threads together and holds tight. The screw will not work loose.

You save production time when you make products with self-locking UNBRAKOs. And you get greater simplicity in design with less bulk and weight. The number of parts you must assemble to achieve full locking action is reduced to the absolute minimum. Lockwashers under screw heads are no longer necessary. Costly wiring of cross drilled heads is eliminated. And in many cases you will save weight and mass by using shorter screws in tapped holes instead of drilling through and using nuts and lockwashers.

Self-locking UNBRAKOs are reusable. They have uniform locking and installation torques—with no galling or seizing on mating threads. They successfully withstand temperatures from —70° to 250°F. And, when screws are properly seated, the locking pellet also functions as a liquid seal.

A complete line of self-locking UNBRAKO socket screw products, in a wide range of standard sizes, materials and finishes, is available through your authorized industrial distributor. Technical data and specifications are detailed in Bulletin 2193. Write us for your copy today. Unbrako Socket Screw Division, STANDARD PRESSED STEEL CO., Jenkintown 28, Pa.

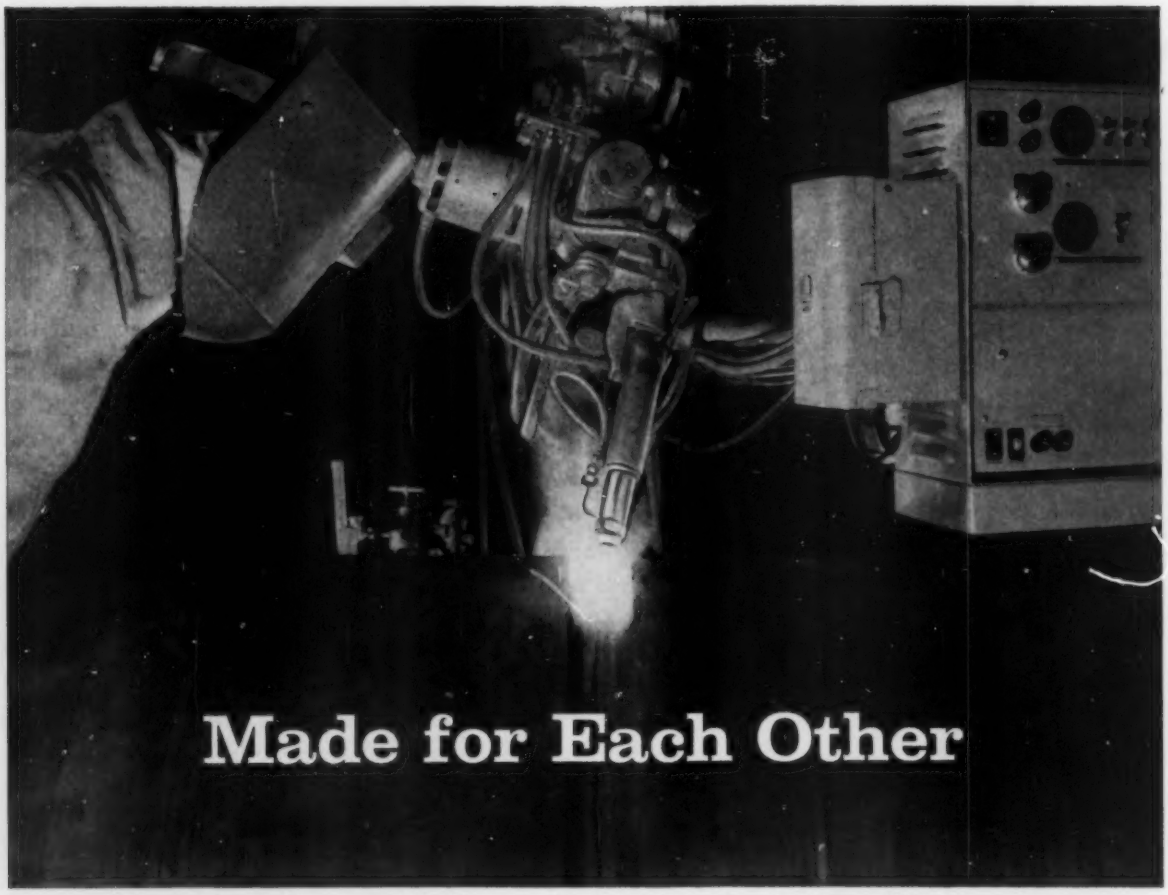
**T.M. Reg. U.S. Pat. Off., The Nylok Corporation*

UNBRAKO SOCKET SCREW DIVISION

STANDARD PRESSED STEEL CO.

SPS

JENKINTOWN PENNSYLVANIA



High-speed sigma welding a 5-in. thick alloy paper mill roll. Note top quality of multipass weld beads.

. . . SIGMA WELDING AND ALLOYED METALS

Because sigma welding joins modern alloys of varying types and thicknesses in fast, clean operations, it has gained recognition by manufacturers throughout industry as the most efficient welding process for a wide range of alloy fabricating jobs.

Combines Advantages

Sigma welding is an extremely versatile process—it joins metal alloys ranging in thickness from 0.035 inch to more than five inches (in multipass operations)—and attains up to four times faster wire deposition than other welding processes.

Gain the full advantages of modern sigma welding . . . Contact your local LINDE Representative for complete information, or write today for free literature.

Linde Air Products Company
A Division of Union Carbide and Carbon Corporation
30 East 42nd Street UCC New York 17, N. Y.
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In Canada: LINDE AIR PRODUCTS COMPANY
Division of Union Carbide Canada Limited, Toronto

The term "Linde" is a registered trade-mark of Union Carbide and Carbon Corporation.

Linde
Trade-Mark

Guarantee TOP Performance and Maximum Life!

Specify THESE TOP QUALITY FEATURES...

(Standard on Miller Cylinders at no extra cost)

Specify CASE HARDENED CHROME PLATED PISTON RODS

On all Air and Hydraulic Cylinders

Benefits To You

CASE-HARDENED Piston Rods (52-54 Rockwell "C") provide practically complete protection against damage from hammer blows, wrench-dropping, mishandling, and similar occurrences. ***Available from Miller at no extra cost.***

The HARD CHROME PLATING over the case-hardened rods protects against scratch-damage and rust. ***Available from Miller at no extra cost.***

Specify "TEFLON" WIPERS

On all Air and Hydraulic Cylinders

Benefits To You

"TEFLON" Rod Wipers and "TEFLON" Hydraulic Piston Rod Seals withstand temperatures from—100°F. to plus 500°F. They are impervious to practically all known chemicals, including the fire-resistant, special, and standard hydraulic fluids in current use. ***Available from Miller at no extra cost.***

Specify TEFLON HYDRAULIC ROD SEALS

On all Hydraulic Cylinders

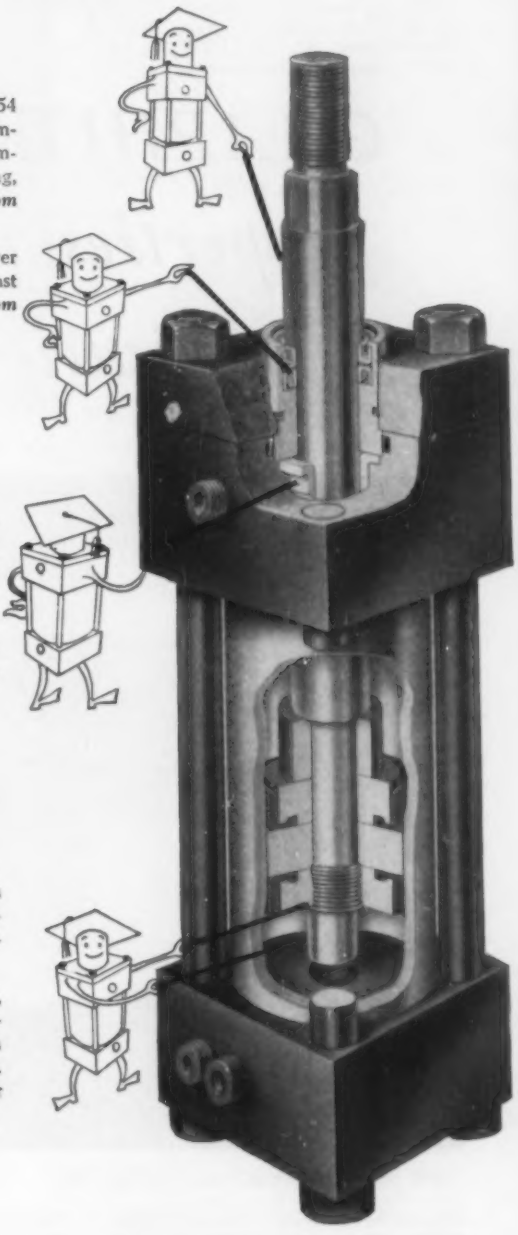
Specify RUST RESISTANT SURFACES

On all Air and Hydraulic Cylinders

Benefits To You

Highest quality Black Ferric Oxide Finish provides rust protection in air cylinder operation and on all cylinders during shipping and installation.

Cylinder heads, caps, mountings, pistons, followers, tie rods, and the unplated portions of the piston rods have this finish ***at no extra cost on all Miller cylinders.*** (This finish not recommended for water service)



NOTE. On all Miller Hydraulic Piston Seals: Leather Cup Seals are *standard*, Piston Ring Seals are optional at *no extra cost*, and "Teflon" Cup Seals are available *at extra cost.*

You may wish to route this entire page to the proper department in your company, by using this handy form. Additional copies on request. →

To (Dept.)_____

"On all our future cylinder requirements, please specify the above quality features."

Signed_____

Title_____

Member of the National Fluid Power Association

SALES AND SERVICE FROM COAST TO COAST

CLEVELAND • YOUNGSTOWN • DAYTON • TOLEDO • CINCINNATI • COLUMBUS
PITTSBURGH • PHILADELPHIA • BOSTON • HARTFORD • NEW YORK CITY
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Miller

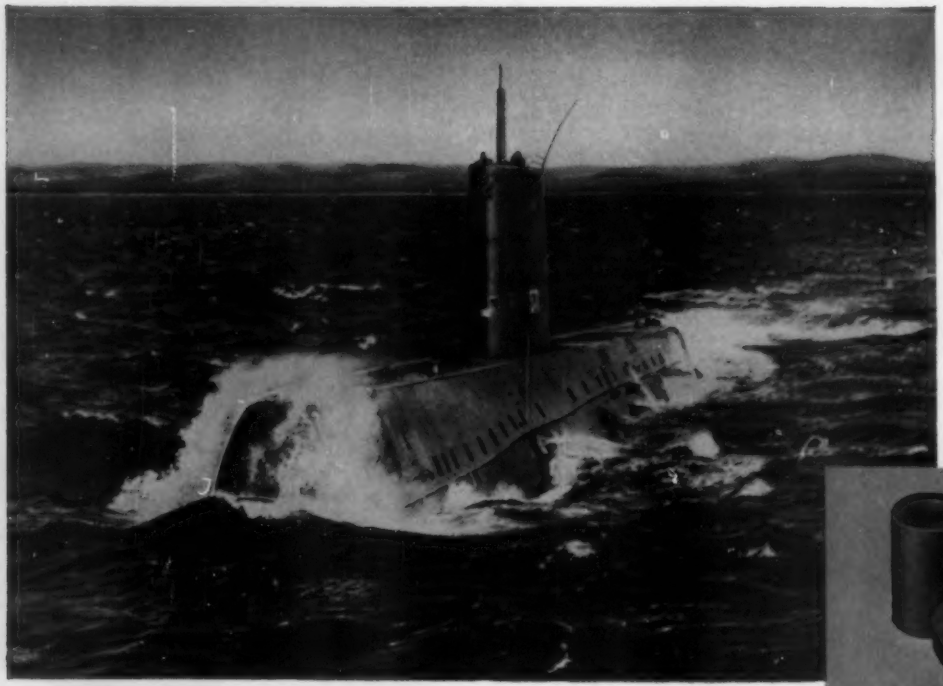
MILLER FLUID POWER DIVISION
FLICK-REEDY CORP.

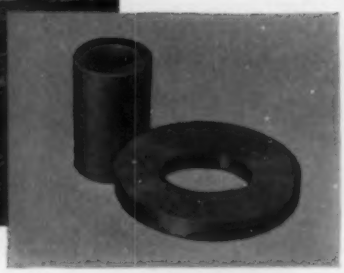
2002-04 N. Hawthorne Ave. **Melrose Park, Ill.**

AIR & HYDRAULIC CYLINDERS • BOOSTERS • ACCUMULATORS
COUNTERBALANCE CYLINDERS

Are your seals or bearings subject to difficult operating conditions?

GRAPHITAR (Carbon Graphite)® *has the specific properties needed in difficult applications like these . . .*



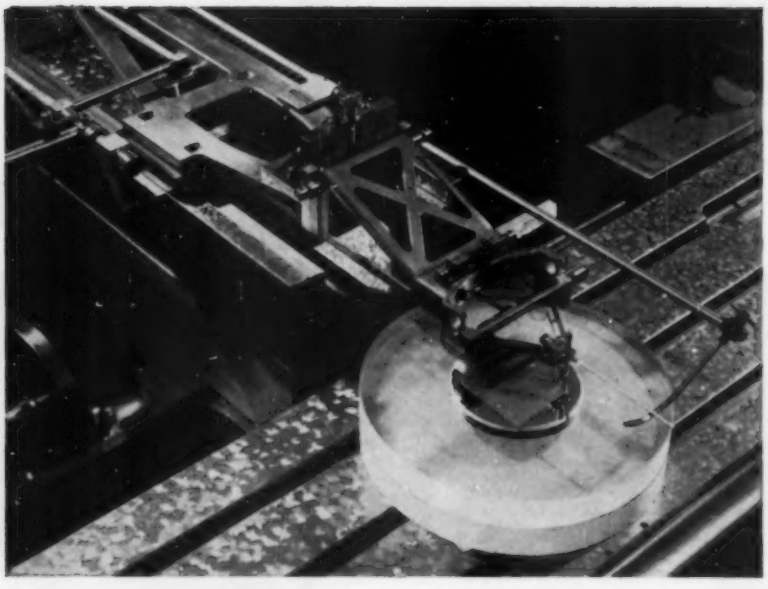


THE MOST IMPORTANT BEARING

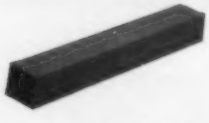
Dependability is vital in the power plant of the Navy's atomic submarine U.S.S. Nautilus which has steamed a total of about 50,000 miles of which approximately half has been submerged. In the reactor cooling system of the submarine, special "canned" motor pumps with integrated pump and drive motor were developed by Westinghouse. The bearings in these pumps, which are made of GRAPHITAR, must withstand high speeds, high temperatures, high pressures and must operate for indefinite periods of time without maintenance and with radioactive water as the only lubricant. Westinghouse Electric Corporation engineers—the builders of the Nautilus' atomic power-plant—find that GRAPHITAR is excellent for this difficult bearing application, because of its strength, durability, self-lubricating properties, and chemical inertness. If your design calls for superior bearings, consider the material that worked on such a demanding job.

THE UNITED STATES

GRAPHITAR® CARBON-GRAPHITE • GRAMIX® SINTERED METAL PARTS • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES

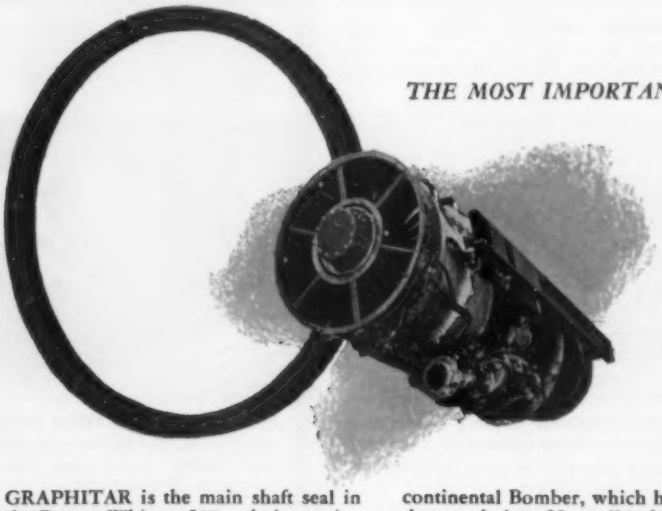


THE MOST EXACTING BEARING



The Bausch & Lomb Optical Co. of Rochester, N.Y., world renowned manufacturer of precision, scientific optical instruments, employs 10 GRAPHITAR bearings in its unique and highly specialized "ruling engine." The GRAPHITAR bearings provide dimensional stability within one-millionth of an inch for micro-inch accuracy in cutting 15,000-30,000 equidistant lines to the inch on 7″ aluminized glass blanks to make diffraction gratings used by science and industry for spectroscopic analysis. Bausch & Lomb engineers have found that GRAPHITAR is unsurpassed as a bearing material where very close tolerances must be maintained and where frequent starting and stopping under heavy loads is a problem. These bearings have contributed greatly to the achievement of extreme accuracy in this application. If you require precision performance as was the case with a "ruling engine" why not use GRAPHITAR?

THE MOST IMPORTANT SEAL



GRAPHITAR is the main shaft seal in the Pratt & Whitney J57 turbojet engine which powers many of our new aircraft, including the huge Boeing B-52 Intercontinental Bomber, which has eight of these turbojets. Naturally, the J57 must perform with utter dependability. One of the components of the J57 is the air/oil seal of GRAPHITAR on the turbine main shaft, and this seal is subjected to tremendous shaft speeds, as well as other taxing physical conditions. GRAPHITAR parts can stand severe operation because they are strong and are virtually unaffected by extremes of speed, pressure, and temperature. If your product develops high speeds or other difficult physical stresses on its parts, perhaps GRAPHITAR components could give it more dependable operation.

THE TOUGHEST APPLICATION

Steel mills are famous for the rough, tough, heavy-duty jobs that they perform. In such difficult steel mill applications as bearings for shear and cut-off tables or coil and slab conveyors, metal-backed GRAPHITAR parts provide exceptional strength and durability. GRAPHITAR alone is a very strong bearing material, and when backed with metal has added resistance to shock. Because of its very low coefficient of friction, GRAPHITAR can operate under heavy loads at high speeds with no lubrication. Can the strength and superb bearing qualities of GRAPHITAR simplify your product design?

Get your copy of Engineering Bulletin No. 20.

GRAPHITAR is compacted from carbon-graphite powders under great pressures, then furnaced at heats near 4500°F. It can be formed in relatively complex shapes and ground to tolerances as close as .0005″. For more information on this strong, light, self-lubricating engineering material, write for our Engineering Bulletin No. 20.

218

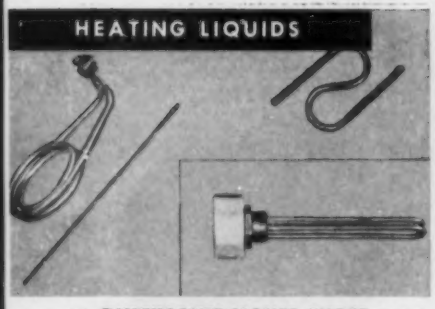
GRAPHITE COMPANY

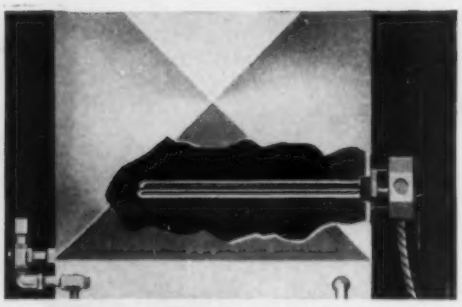
DIVISION OF THE WICKES CORPORATION, SAGINAW, MICHIGAN

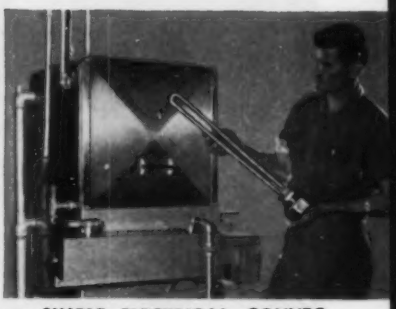
DESIGNING HEAT INTO YOUR PRODUCT?

General Electric Metal-sheath Heaters Save Time in Both Production and Design

HEATING LIQUIDS





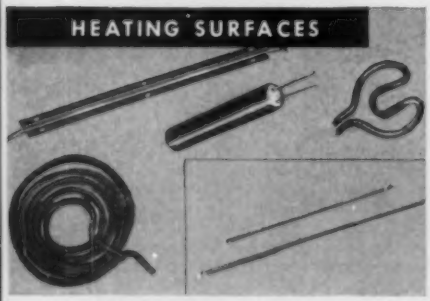


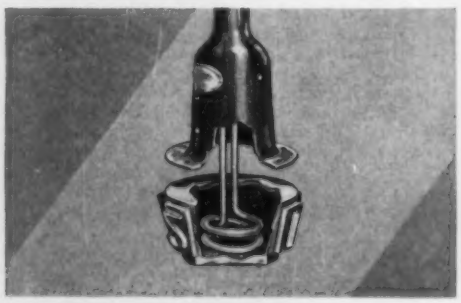
1 **DISHWASHER MAKER CHOSE** screw-in type G-E immersion heater from wide variety available. Threaded fitting speeds installation.

2 **DIRECT CONTACT WITH LIQUID** over entire heating surface provides fast heat-up and minimizes heat-transfer losses. Thermostat is easily installed for temperature control.

3 **SIMPLE ELECTRICAL CONNECTIONS,** after heater is screwed into place, complete installation. Assembly is fast, easy.

HEATING SURFACES



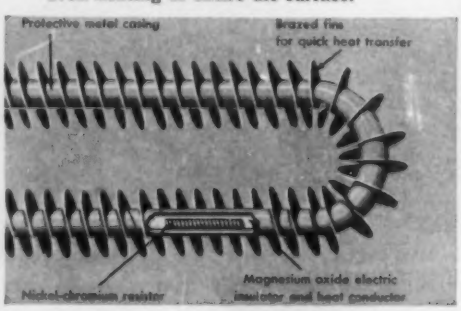


1 **EASILY FORMED WITHOUT BREAKING** . . . this is reason why General Electric tubular heaters are choice of branding-iron manufacturer.

2 **STURDY METAL SHEATH** permits casting heaters right into die body—without production headaches. Result is dependable, even heating of entire die surface.

3 **LONG LIFE** comes from combining quality die work with dependable G-E heaters. Users report up to 12 years life.

HEATING PROCESS AIR


Protective metal casing
Brazed fins for quick heat transfer
Nickel-chromium resistor
Magnesium oxide electric insulator and heat conductor

1 **LARGE RADIATING SURFACE** per unit length of G-E finned tubular heaters allows maximum air circulation in forced-convection heating.

2 **COMPLETELY ENCLOSED** heating element of General Electric finned heaters is protected from dust in the air stream, eliminating trouble from short circuits.

3 **PRE-FORMING TO YOUR SPECS** reduces on-site fabrication time and costs, and helps solve problems of installation.

HANDY SELECTOR GUIDES . . .

Learn how to pick the right G-E heater for your job.

NAME.....

COMPANY.....

ADDRESS.....

CITY.....STATE.....

Mail to Section D723-11, General Electric Company, Schenectady 5, N. Y.

- ☐ GEA-6113 Handy Selector Guide for Metal Melting
- ☐ GEA-6146 Handy Selector Guide for Surface Heating
- ☐ GEA-6305 Handy Selector Guide for Water, Alkaline or Plating Baths
- ☐ GEA-6306 Handy Selector Guide for Heating Oil
- ☐ 1957 Catalog of Heaters and Devices

For more information, contact your local G-E Apparatus Sales Office

GENERAL ELECTRIC

problem:

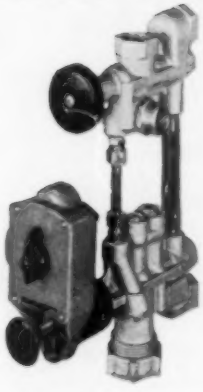
find a low-friction seal that positively seals at extremely low pressures

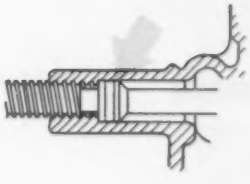
new answer:

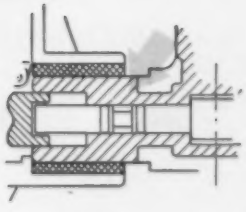
minnesota rubber's money-saving new

QUAD® RING

evidence:







THE LINDSAY COMPANY, world's largest manufacturer of automatic home water softeners, uses three QUAD RINGS in its newest valve. Lindsay tested O-rings in the valve, but O-rings leaked at very low pressures. Then Lindsay tested QUAD RINGS, a revolutionary new seal originated and manufactured by Minnesota Rubber. QUAD RINGS sealed perfectly no matter how low the pressure. The Lindsay Company also found that it could open some of the tolerances on the valve parts—and save money—because QUAD RINGS give such a good seal with low friction.

QUAD RINGS are injection molded. Denser, tougher. 4-lip action even seals at less than 1 psi! Only 60-100 micro-inch groove finish needed. No parting line on sealing surface. Eliminates "spiral twist".

QUAD RING is Minnesota Rubber and Gasket trade mark

free samples and technical brochure. Write today to:

minnesota rubber and gasket company

Originators of modern rubber injection molding

Dept. 201, 3630 Wooddale Ave., Minneapolis 16, Minnesota, Phone WEst 9-6781

Riveting With a Hammer in Blind or Open Applications

Elimination of special riveting tools can mean faster production, lower costs, no down time.

J. K. BARRY, M. E.

The use of blind rivets installed with only an ordinary hammer from one side of the job offers a highly simplified method of fastening. Speed, convenience and *low installed cost* make Drive Riveting preferable not only for blind joints, but for fastening many parts that can be reached from either side.

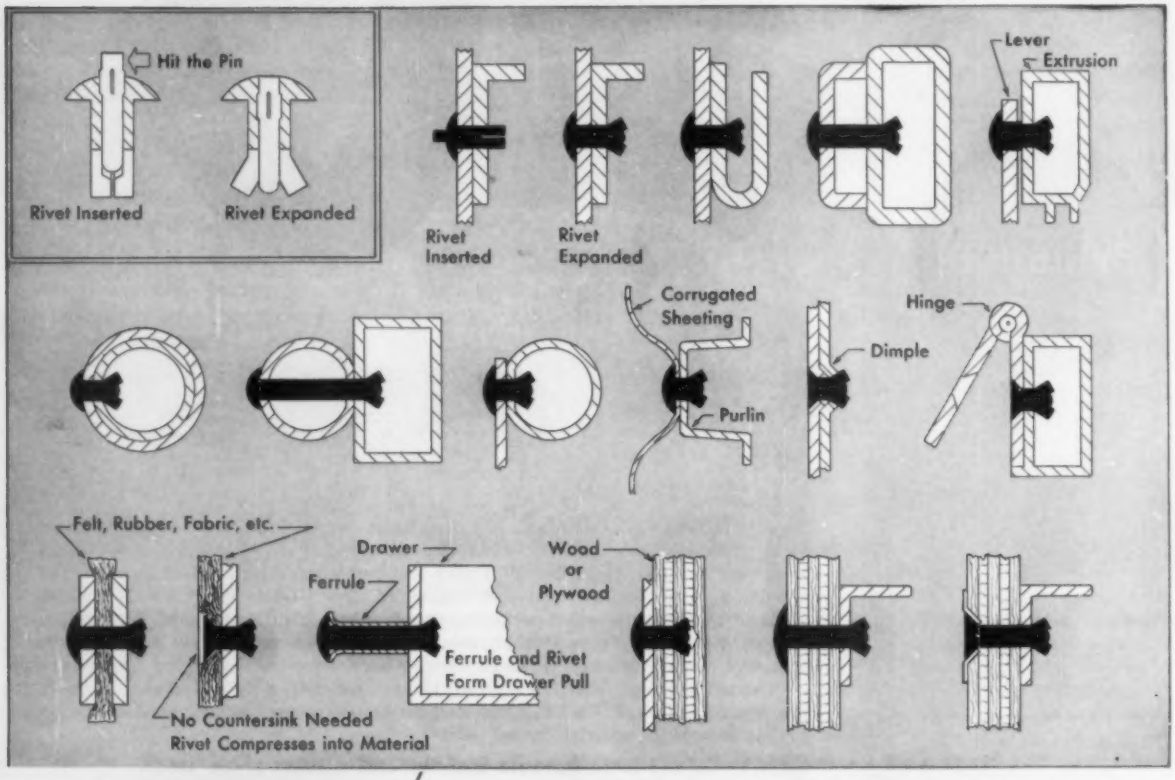
The Southco Drive Rivet has a cored, slotted body with a grooved pin protruding from its head. When the rivet is inserted through parts to be fastened, the pin is driven flush with the rivet head causing the expanding prongs to form a blind head behind the rear sheet. No further finishing is necessary, since the pin seats itself permanently to complete the smooth head contour.

Drive Riveting has five major advantages:

1. No investment in special tooling.
2. No lost time for tool repairs.
3. No limitation on the number of men who can install rivets.
4. Speed comparable to nailing.
5. Only one man is needed.

Widely used in truck bodies, storm doors, metal buildings and hundreds of other industrial applications, Southco Drive Rivets make a secure, vibration-proof joint. A wide range of head styles, diameters and grip lengths is available.

RECOMMENDED APPLICATIONS FOR DRIVE RIVETING



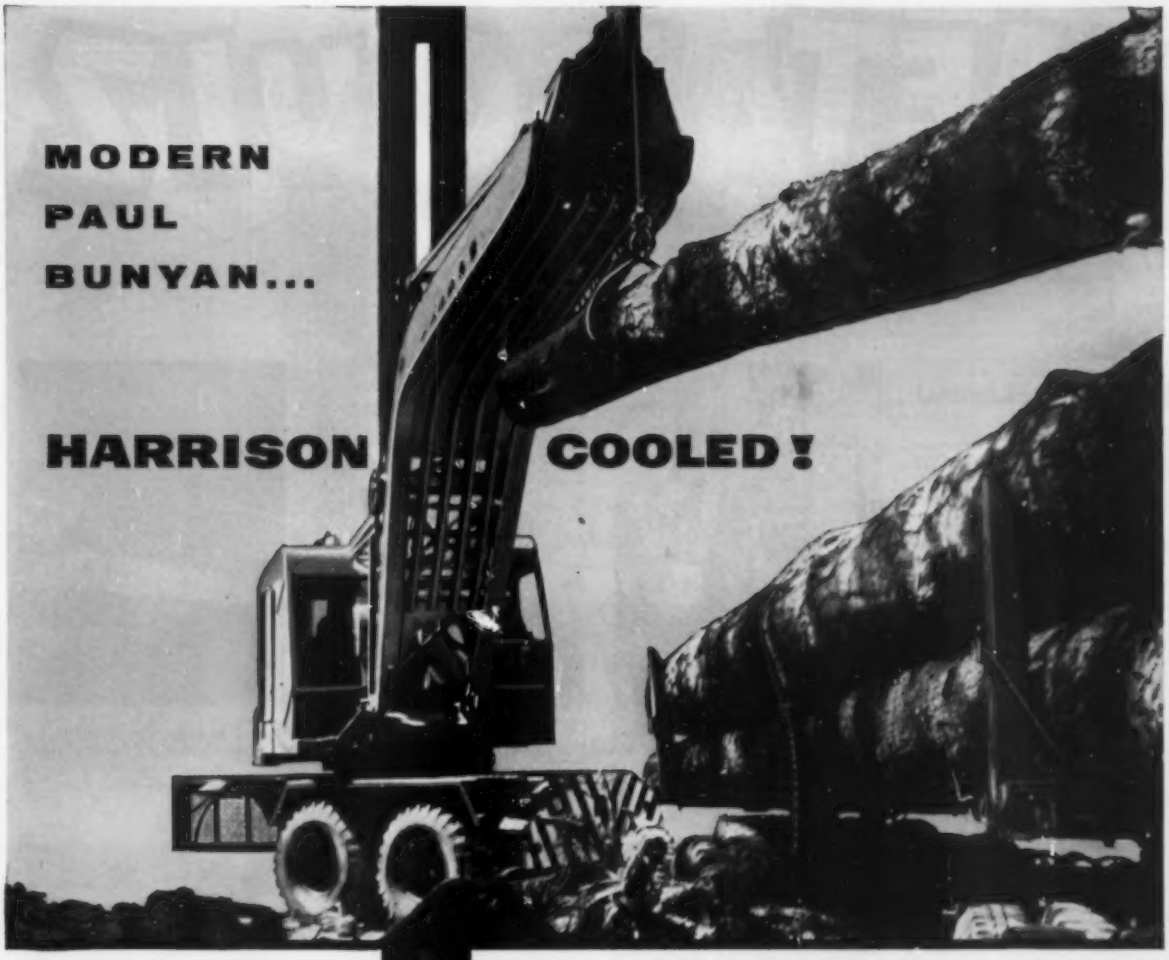
SOUTHCO FASTENERS

LION

©1956

Southco Div., South Chester Corporation

236 Industrial Highway, Lester, Pa.



Diesel-Powered Log-Loader Runs COOL with HARRISON

Heat-leveller for a mighty lumberman! That's Harrison's job on this Detroit Diesel powered Link-Belt log-loader. Hoisting huge logs day in and day out is a hot, grueling job. But Harrison's heavy-duty, high-capacity oil cooler holds heat down . . . keeps temperatures level. For temperature control is our business at Harrison—we're specialists in heat control for giant, off-the-road equipment. And that's not all . . . you'll find Harrison heat exchangers on the most advanced aviation, marine, railroad and industrial equipment. If you have a cooling problem, look to Harrison for the answer!

Watch "WIDE WIDE WORLD" Sundays on NBC-TV

TEMPERATURES MADE TO ORDER

GM GENERAL MOTORS

HARRISON

RADIATOR DIVISION, GENERAL MOTORS CORP., LOCKPORT, N.Y.

METAL QUIZ

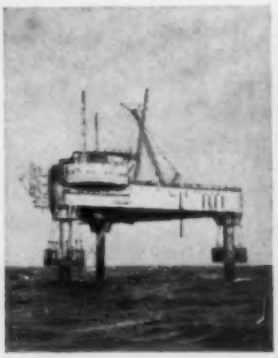
Each of these problems was solved successfully with an Inco Nickel Alloy
Can you tell which one proved to be the answer?

Number the picture captions!

1. **"S" Monel** hard-grade nickel-copper cast alloy
2. **Inco Nickel**
3. **"K" Monel** age-hardenable nickel-copper alloy
4. **Inconel** nickel-chromium alloy
5. **Monel** nickel-copper alloy
6. **Inconel "X"** age-hardenable nickel-chromium alloy
7. **Monel "403"** non-magnetic nickel-copper alloy

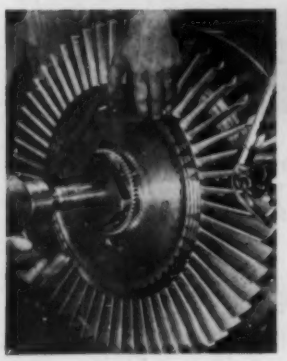
See answers below

☐ **Oil well drill collar** — Needed: non-magnetic metal with high strength. Which Inco Nickel Alloy . . . ?

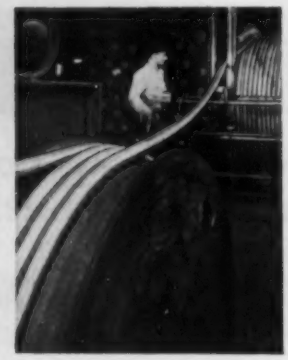


☐ **Radar platform "leggings"** — Needed: resistance to abrasion and marine corrosion. Which Inco Nickel Alloy . . . ?

☐ **Jet engine flame tube** — Needed: oxidation and corrosion resistance at jet engine temperatures. Which Inco Nickel Alloy . . . ?

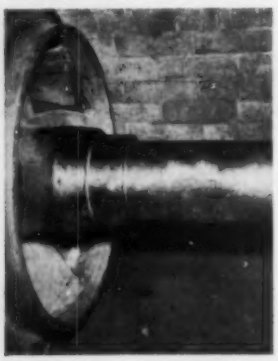


☐ **Gas turbine blades** — Needed: hot strength up to 1500°F., low coefficient of expansion. Which Inco Nickel Alloy . . . ?



☐ **Submarine cable sheathing** — Needed: non-magnetic metal resistant to marine corrosion. Which Inco Nickel Alloy . . . ?

☐ **Ultrasonic drill** — Needed: high magnetostrictive ability to produce ultrasonic vibrations. Which Inco Nickel Alloy . . . ?



☐ **Shaft sleeve for salt water pump** — Needed: extra-hard casting alloy that resists corrosion. Which one . . . ?

You may take this kind of quiz *again* . . . and soon! *Your* design may require a metal that resists corrosion . . . or wear . . . or high temperatures. Or one that meets some destructive *combination* of conditions.

Then look into the Inco Nickel Alloys. First step: send for "Standard Alloys for Special Problems." This fact-filled booklet describes the properties of many useful metals . . . shows just the kind of problem each has solved. Write for a copy . . . do it *now!*

*Trademark of The International Nickel Company, Inc.

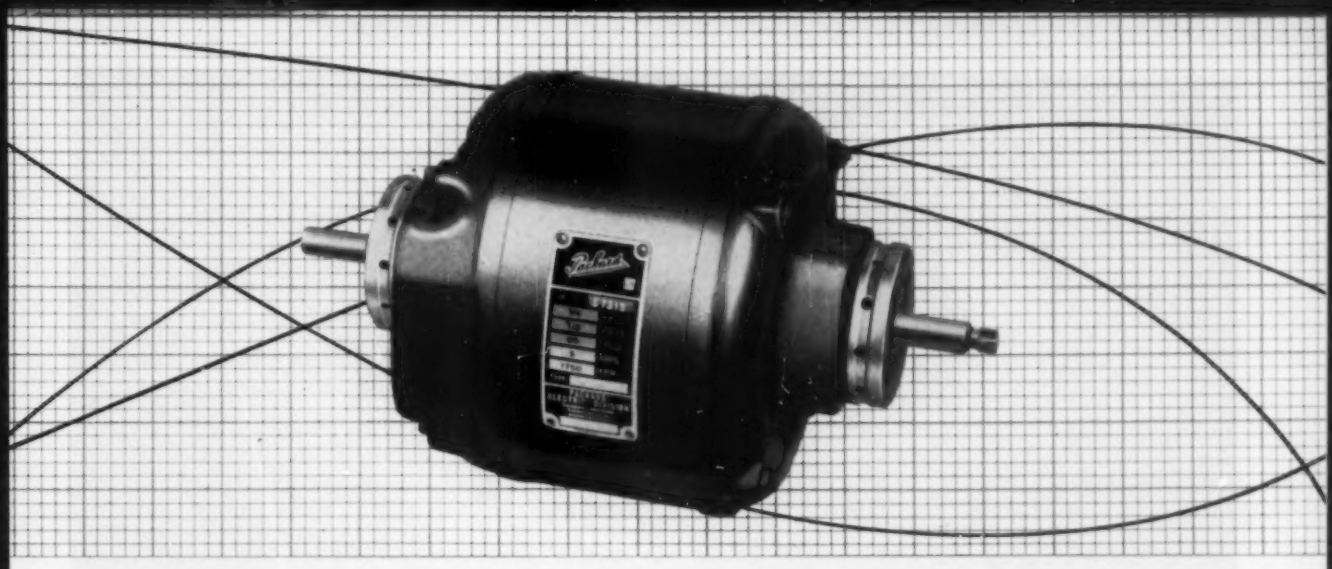
THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York 5, N. Y.

INCO TRADE MARK

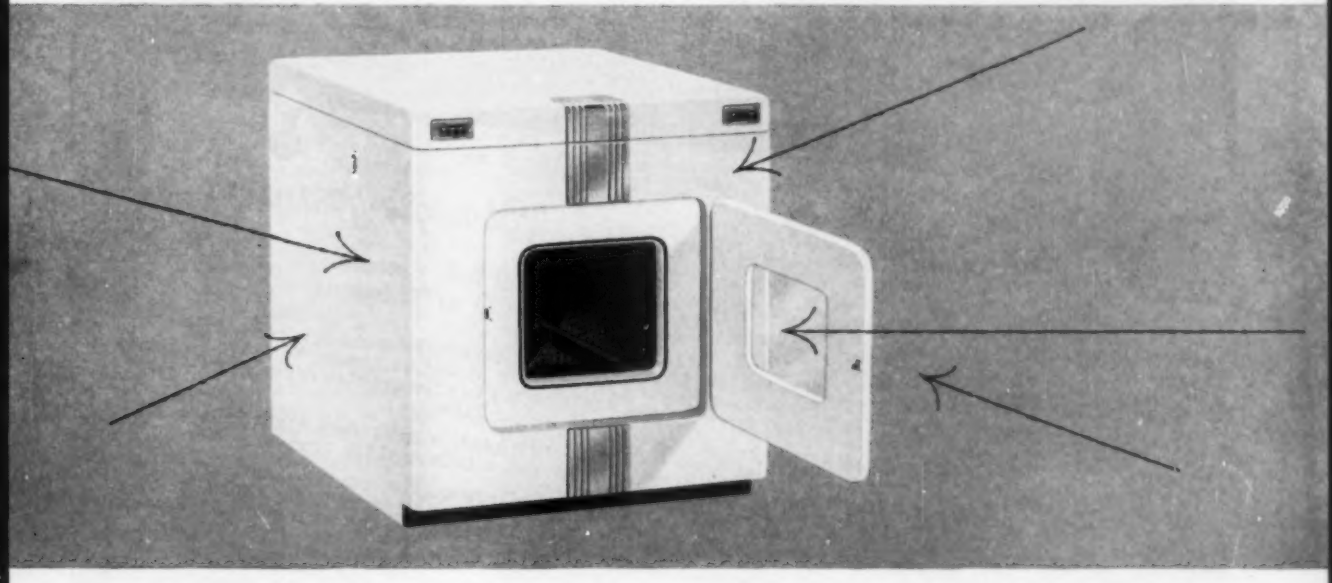
Nickel Alloys

Monel* • "R" Monel* • "K" Monel* • "KR" Monel* • "S" Monel* Inconel* • Inconel "X"* • Inconel "W"* • Incoloy* • Incoloy "T"• Ni-o-nel • Nimonic* Alloys • Nickel • Low Carbon Nickel • Duranickel*

Oil well drill collar: 3. "K" Monel
Radar platform "leggings": 5. Monel
Jet engine flame tube: 4. Inconel
Gas turbine blades: 6. Inconel "X"
Submarine cable sheathing: 7. Monel "403"
Ultrasonic drill: 2. Inco Nickel
Pumps' shaft sleeve: 1. "S" Monel



PACKARD ELECTRIC / *Because this motor was custom-tailored*



FHP MOTORS / *this dryer is built better at lower cost!*

Packard Electric direct factory sales and engineering contact consistently pays off. In this case it did for a dryer manufacturer.

The payoff came in a motor custom-tailored to dryer requirements . . . not merely a conveniently adapted motor. This means that the motor has the exact characteristics—speed, power and torque—for its job. Because of that, it could be advantageously priced.

What's more, it can be supplied with power supply cord already attached—complete and ready for installation. This results in still more savings.

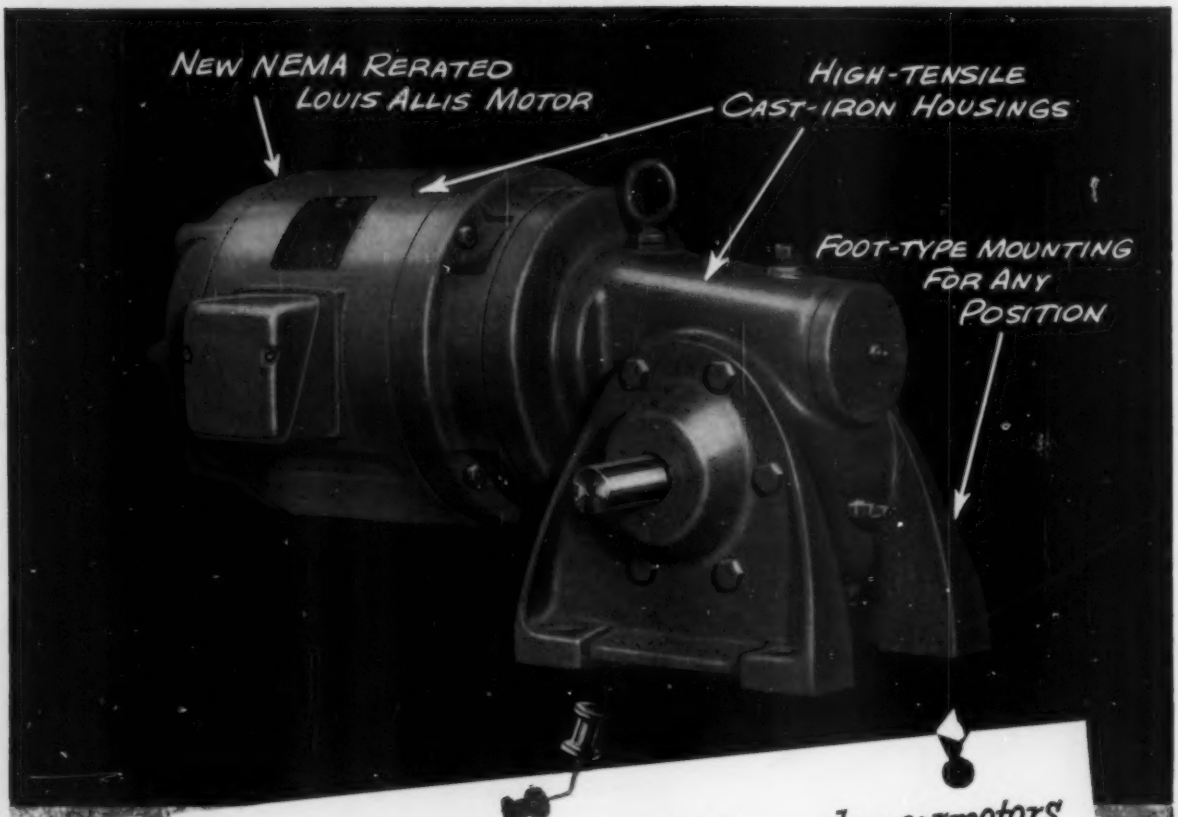
Packard Electric research and engineering teams are busy today developing new motors. And as always, our objective is to enable customers to produce better, lower priced products in the future.

Packard *Electric*

Warren, Ohio

GM GENERAL MOTORS

Division of General Motors



Louis Allis announces its L.A. line of right-angle gearmotors

Now available with new NEMA rerated L.A. motors for all applications — in sizes from 1/3 to 30 hp

Before we go into the many design features of this compact gearmotor, let's take a look at a few other advantages:

First of all, you can get either foot- or flange-mounted units. Secondly, you can have any motor enclosure you want. And finally, you can have any electrical or mechanical modification needed for any specific application.

In other words, here's a line of gearmotors ruggedly designed, versatile and efficient—to give you a sound answer to your right-angle gearmotor drive problems. Here's why:

- Both gear and motor housings are made of high-tensile cast iron to provide maximum strength, rigidity, and compactness.
- The worm, carefully machined from hardened alloy steel, is ground to close tolerances to give greater efficiency and longer life.
- The worm gear is cut from a high grade of wear-resistant alloy bronze.
- A double-row angular contact bearing and a ball bearing provide for radial and thrust loads on the worm shaft.
- The output shaft is mounted in tapered roller bearings for maximum load-carrying capacity.
- Ample oil-bath lubrication assures longer life and minimum maintenance.
- Special oil seals on all shafts keep the oil in--dirt out and permit any mounting arrangement.

Here's a line of right-angle gearmotors that's very easy to apply. Standard speed range from 7-1/2 to 300 rpm--special speeds also are available.

Flange-mounted right-angle gearmotor with new L.A. line explosion-proof motor

GM-103

THE LOUIS ALLIS CO.
MILWAUKEE 7, WISCONSIN

STAINLESS STEEL MAKES THE DIFFERENCE

...its effect on modern equipment

Sanitation ... easy maintenance ... inherent cleanliness ... ready adaptability to a host of different shapes and forms—these are a few of the reasons why more and more designers of food processing, dairy and beverage equipment specify stainless steel.

You'll find it in tubing, tanks, bulk coolers, autoclaves and dozens of other vital pieces of equipment in many different industries.

Stainless steel's superior resistance to corrosion ... ready availability in scores of work-saving standard shapes adaptable to many needs ... ease of machining, forming, joining and casting combine to give equipment producers greater freedom of design.

For more information about stainless steel and its growing effect on equipment design and selling problems, see your stainless steel supplier or write ELECTROMET—leading producer of more than 100 alloys for the metal industries, including chromium and manganese used for making stainless steels.

ELECTRO METALLURGICAL COMPANY
A Division of
Union Carbide and Carbon Corporation
30 E. 42nd Street UCC New York 17, N. Y.

METALS DO MORE ALL THE TIME ... THANKS TO ALLOYS

Electromet
TRADE-MARK

Sanitation is a powerful selling tool in the beverage, food processing and dairy fields. That's why the use of sanitary, easy-to-clean stainless steel is growing so fast.

(*Advertisement*)

SPECIAL REPORTS ON FINISHING NON-FERROUS METALS

NUMBER I—Decorative, Corrosion-Resistant Finishing with Iridite

Chromate conversion coatings are well known and accepted throughout industry as an economical means of providing corrosion protection, a decorative finish or a good paint base for non-ferrous metals. However, continued developments are so rapid and widespread that many manufacturers may not be completely aware of the breadth of application of this type of finish. Hence, this digest of current information; to bring you up to date on the many ways in which you can combine salable appearance with durability in one finish at a competitive price advantage. Report II on paint base, corrosion-resistant finishes and Report III on chemically polished, corrosion-resistant finishes are available on request.

First, as a basis for this discussion, a "decorative" finish is considered as any chromate film that is used as a final finish in itself. It may be truly decorative in that its sole purpose is to enhance the beauty of the product. For example, a bright chrome-like finish or a pleasing bronze appearance are among the many effects that can be obtained. It may be functionally decorative in that it reduces reflectivity for camouflage purposes or provides a means of color-coding parts. But, in all cases, the Iridite films protect the metal against corrosive attack.

Iridite finishes are now available for all commercial forms of the more commonly used non-ferrous metals, including zinc, cadmium, aluminum, magnesium, silver, copper, brass and bronze. These films can produce a wide variety of pleasing appearances. The basic colors of the Iridite coatings are grouped below by metals.

ZINC and CADMIUM: Metallic bright, light iridescent, iridescent yellow, bronze, olive drab.

COPPER, BRASS, BRONZE: Metallic bright, yellow.

ALUMINUM ALLOYS: Clear, iridescent yellow, brown.

MAGNESIUM ALLOYS: Metallic bright, iridescent yellow-red, brown.

SILVER: Metallic bright.

In addition, many films can be modified by bleaching or by dyeing. Among the dye colors available are various shades of red, yellow, green, blue or black.

Depending upon the metal and the Iridite used, corrosion resistance of clear and bright films ranges from mild passivity to as high as 500 hours in salt-spray; on heavier dark films, salt-spray resistance ranges from approximately 100 to 1000 hours.

It is this combination of decorative and corrosion resistant properties that accounts for the widening use of Iridite finishes. For example, Iridites #4-73 and #4-75 (Cast-Zinc-Brite) make possible for the first time, a combination of lustrous chemical polishing of the as-cast surface of zinc die castings and good resistance to corrosion. Further, in many cases, sizeable savings in the cost of buffing and electroplating are realized.

On many steel parts, a simple system of zinc or cadmium plate and bright Iridite is used instead of more costly electroplated finishes to provide a bright, decorative and protective finish with tremendous savings in material, equipment and labor.

In finishing aluminum, where corrosion resistance or paint adherence is the prime consideration, the aircraft industry has all but abandoned the anodizing process in favor of recently developed chromate conversion coatings, among them Iridite #14 and #14-2 (Al-Coat). These formulations and their method of application can be varied to retain the original metallic appearance while providing acceptable corrosion resistance, or to produce a fully colored brown finish that offers exceptional corrosion protection. Again, time and manpower savings are astounding—one company saved at least $15,000 a year on maintenance of racks alone and another $40,000 on materials and labor in only nine months. In addition, of course, hundreds of thousands of dollars are saved by eliminating the need for expenditures for generators, heating equipment and racks.

Iridites are widely approved under both Armed Services and industrial specifications because of performance, low cost and savings of materials and equipment.

In planning or designing, you should consider the many other characteristics of Iridite finishes which may enter into the specific problem. In addition to having decorative and protective functions, these chromate coatings form an excellent base for organic finishes and bonding compounds. They have low electrical resistance. Some can be soldered and welded. The Iridite film itself does not affect the dimensional stability of close tolerance parts.

You can see then, that with the many factors to be considered, selection of the Iridite best suited to your product requires the services of a specialist. That's why Allied maintains a staff of competent Field Engineers—to help you select the Iridite to make your installation most efficient in improving the quality of your product. You'll find your Allied Field Engineer listed under "Plating Supplies" in your classified telephone book. Or, write direct and tell us your problem. Complete literature and data, as well as sample part processing, is available. Allied Research Products, Inc., 4004-06 E. Monument Street, Baltimore 5, Maryland.

WHAT IS IRIDITE®

Briefly, Iridite is the tradename for a specialized line of chromate conversion finishes. They are generally applied by dip, some by brush or spray, at or near room temperature, with automatic equipment or manual finishing facilities. During application, a chemical reaction occurs that produces a thin (.00002" max.) gel-like, complex chromate film of a non-porous nature on the surface of the metal. This film is an integral part of the metal itself, thus cannot flake, chip or peel. No special equipment, exhaust systems or specially trained personnel are required.

OOPS!

SIGHTS of rockets swooshing heavenward become more and more familiar as we thumb through today's industrial publications. The recalcitrant rocket shown on this page indicates that things *can* go wrong in research, and we don't claim that the absence of a Sanborn oscillographic recording system somewhere along the line was the reason for this disappointing trajectory.

What we do wish to say is that Sanborn equipment is playing an increasingly vital part in rocket development. Used in the laboratory to record flight behavior simulated by analog computers, and in plotting rooms at testing bases to tape down telemetered data, Sanborn "150's" are helping rockets to get and stay where they belong.

You can see Sanborn systems in many other places, too. Oil fields, electronic component production lines, machine tool plants, hydraulic testing laboratories, numerous aircraft manufacturers, computing facilities . . . are putting single to 8-channel Sanborn systems to work. (Most are housed in vertical mobile cabinets, while those in the "field" are often divided into portable packages for each instrument.) All of them give their users inkless, permanent recordings in true rectangular coordinates, one percent linearity, as many as nine chart speeds, and the efficiency (and economy) inherent in Sanborn unitized design. A dozen different plug-in preamps further extend their value, by making changeover to new recording inputs a quick and easy procedure.

SANBORN COMPANY

CAMBRIDGE 39, MASSACHUSETTS

8-, 6-CHANNEL 4-CHANNEL 2-CHANNEL 1-CHANNEL 2-, 4-, 6-, 8-CHANNEL ANALOG COMPUTER SYSTEMS

Which way rockets are going may not be a primary concern of yours. But if recording problems are, you're apt to find some interesting and useful answers in Sanborn's 16 page "150 System" catalog. Write to us for a copy.

PowerGrip "TIMING" BELTS

"Here's how this hobbing machine was made 37% more productive"

says Plant Engineer "GRIP" POWERS

Schematic of an imported Precision Gear Hobber, used to cut Naval Bronze Worm Wheels for gear head motors. Prior to the installation of U. S. PowerGrip "Timing"® Belts on the main drive motor (A), belt slippage—on three ordinary belts—kept daily production to 40 wheels per day. Now with just one Heavy-Duty PowerGrip "Timing" Belt (TB), there is no slippage—even under high loads and exposure to oils used in cutting gems—and they're getting 55 wheels per day without any further labor or equipment involved. That means considerable savings over a run of 2000 wheels.

"Grip" Powers is showing you a true story of how one East Coast gear manufacturer utilized the unique ability of U. S. PowerGrip "Timing" Belts to step up production. It's just one of many examples of how U. S. PowerGrip "Timing" Belts simplify and improve a power transmission unit.

For the design of hand tools, drill presses, saws, electric typewriters—from fleapower to 1,000 horsepower—get U. S. PowerGrip "Timing" Belts.

These belts—plus expert engineering service—are obtainable at the 28 "U. S." District Sales Offices, "U. S." power transmission distributors, or contact us at Rockefeller Center, New York 20, N. Y. In Canada, Dominion Rubber Co., Ltd.

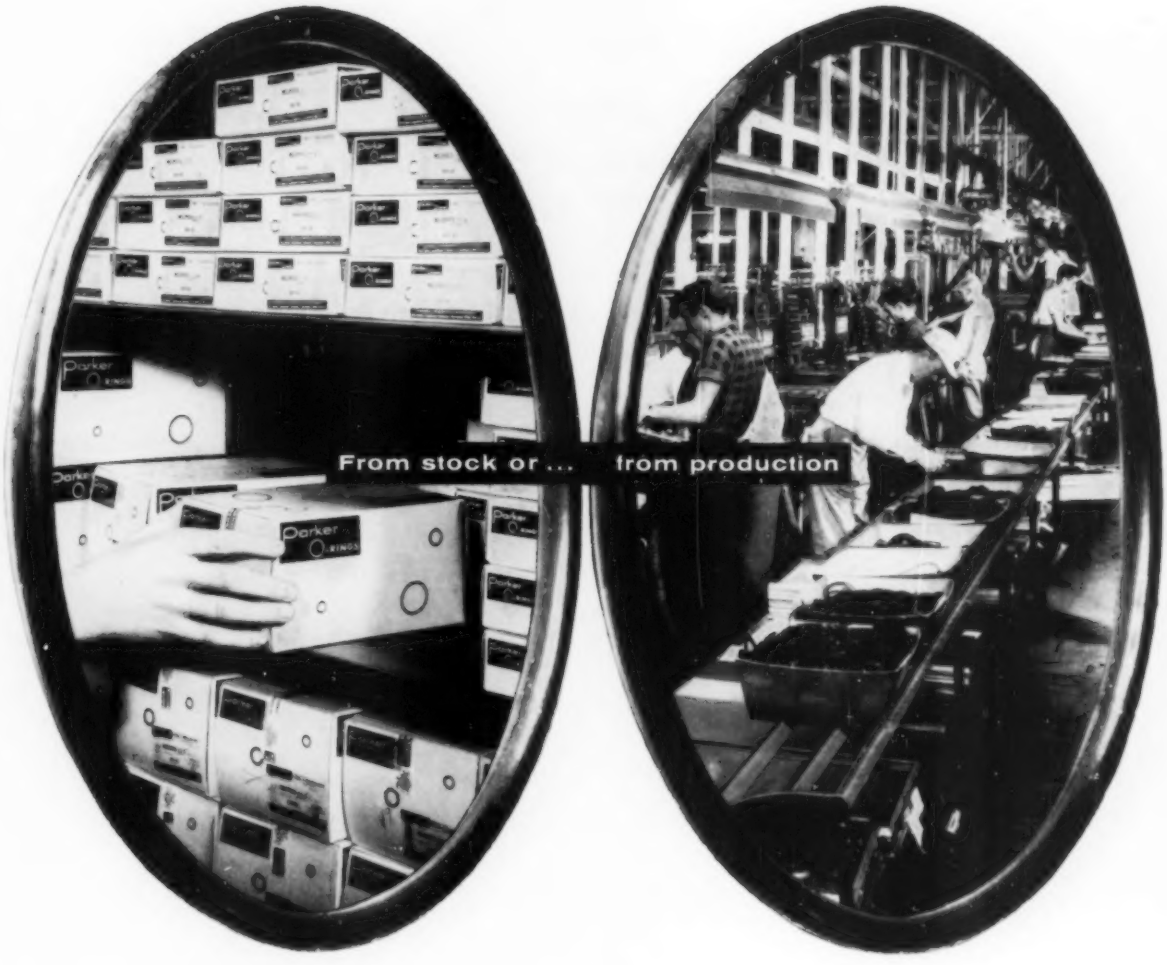
U. S. PowerGrip "Timing" Belts offer all these advantages:

- close to 100% efficiency.
- constant angular velocity.
- imbedded with steel cables for high tensile strength.
- no slippage, no take-up—allows short centers, high ratios.
- absence of metal-to-metal contact—eliminates need for lubrication and housing devices.
- handles speeds up to 16,000 F.P.M. or so slow as to be imperceptible to the eye.

Mechanical Goods Division

United States Rubber

No matter how many you need...



we offer fast delivery of O-rings!

Parker can meet *any* demand for O-rings. Factory stocks (millions of O-rings) are maintained in Chicago, Cleveland and Los Angeles. Large warehouse stocks are available at more than 50 Parker O-ring distributors. You can get standard sizes of AN, MS, industrial specifications, etc., right off the shelf. (And we have over 296 standard O-ring sizes with many different standard compounds.) Parker also has the production facilities to handle "specials" and volume requirements.

From Parker you get exactly the right O-ring for your specific requirements. Our engineering service will help you with any designing problems. We invite you to prove by comparison tests how Parker O-rings seal better and last longer.

Parker
Hydraulic and fluid system components

RUBBER PRODUCTS DIVISION
Section 522-U
The Parker Appliance Co.
17325 Euclid Ave., Cleveland 12, Ohio

☐ Please send O-ring Size Catalog No. 5701

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GENERAL ELECTRIC ANNOUNCES . . .

NEW Industrial

Direct-current Motor

KINAMATIC* a new standard in direct-current motors, gives your machines wider speed ranges, greater output

To meet modern industrial needs for faster, more automatic, more continuous production, General Electric has designed an entirely new direct-current motor—the d-c Kinamatic.

Designed for Automation—Now, a direct-current motor has been designed for the modern job it has to do—either as individual motor drive or in regulating systems. The new General Electric d-c Kinamatic motor supplies the wide speed range and versatility required for today's manufacturing methods. It is designed for the close control of machines and split-second timing of processes essential to higher output.

Accelerated Production—The new d-c Kinamatic motor will modernize your equipment, give it increased power, higher speeds, greater output capacity. With the quick-acting G-E Kinamatic motor, your machines will process a greater variety of products . . . faster . . . easier . . . and with less maintenance and spoilage.

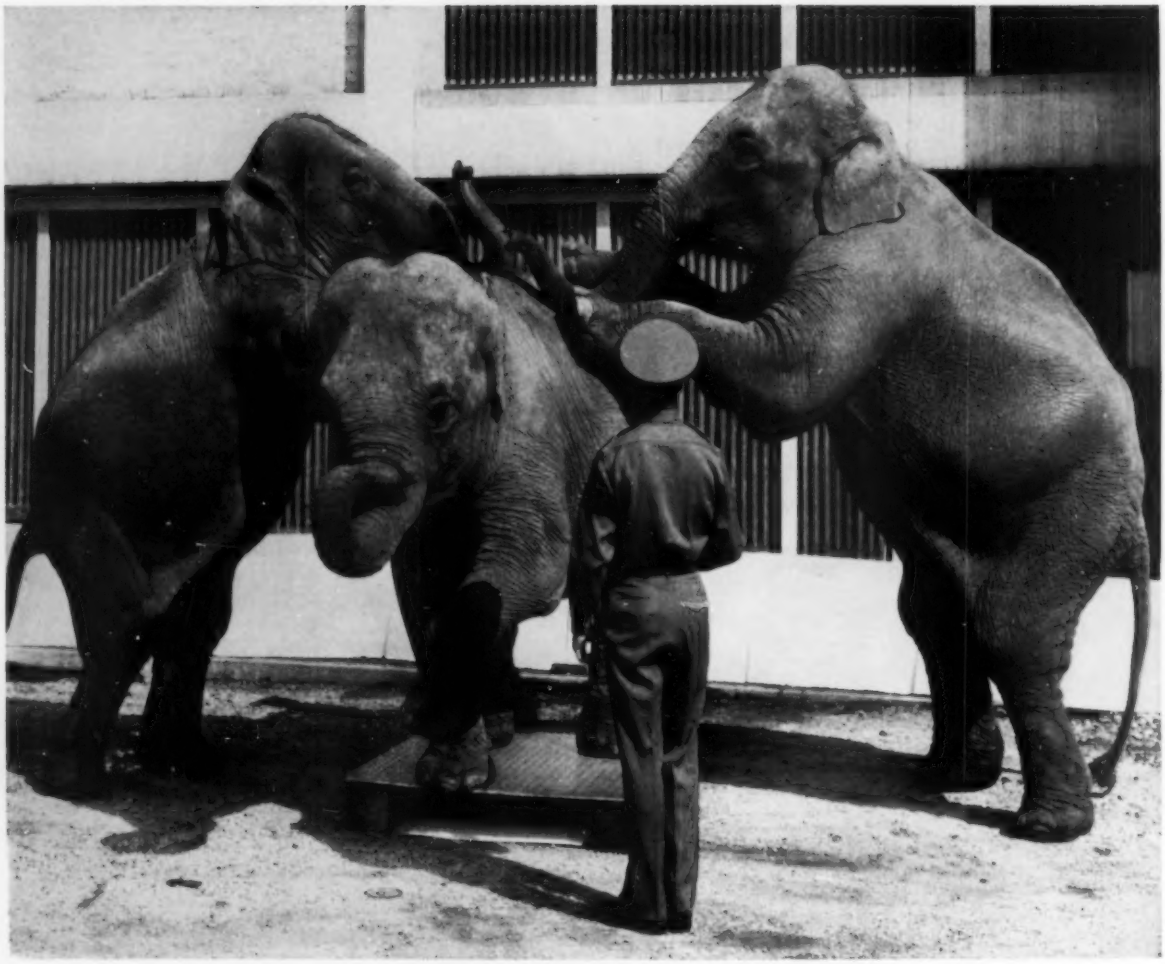
More Powerful—By combining advanced design with improved materials and manufacturing techniques, General Electric engineers have packed more power into the entire Kinamatic line. The powerful Kinamatic motor, with new stamina and durability, is ready to become one of your most effective weapons for keeping costs down, for meeting competition, for boosting productivity levels.

Engineering Help—Industrial specialists in 149 conveniently located General Electric Apparatus Sales Offices have the complete story on how the new d-c Kinamatic motors and generators can benefit your operation. For full details, contact your G-E Sales Representative, or write for Bulletin GEA-6355. *Direct Current Motor and Generator Department, General Electric Company, Erie, Pennsylvania.* 813-1

* Trade Mark of the General Electric Company

Progress Is Our Most Important Product

GENERAL ELECTRIC



2-TON BABIES PROVE 4-WAY'S STRUCTURAL STRENGTH

These frolicsome 2-ton circus babies demonstrate the ability of Inland 4-WAY Safety Plate to support tremendous weights. Because of 4-WAY's rugged strength, this 4′ x 4′ plate bears up under 4,000 pounds of pudgy pachyderm without a hint of strain.

The extreme structural strength of Inland 4-WAY Safety Plate is an important factor in plant safety. 4-WAY is not just another flooring surface material, but a steel plate that can be used as a structural member.

Strength, however, is only one of the advantages that 4-WAY offers. Its **slip-resistance, durability, attractive appearance, ease of application, fire resistance, ease of fabrication and cleanability** provide you with a combination of features unequalled by any other materials. Where can *you* use Inland 4-WAY Safety Plate? There are dozens of places in every plant where it can pay off in man hours saved . . . in providing safer, cleaner surfaces . . . in boosting general efficiency. For helpful suggestions and useful information, write to Dick Prendergast, Room 1262.

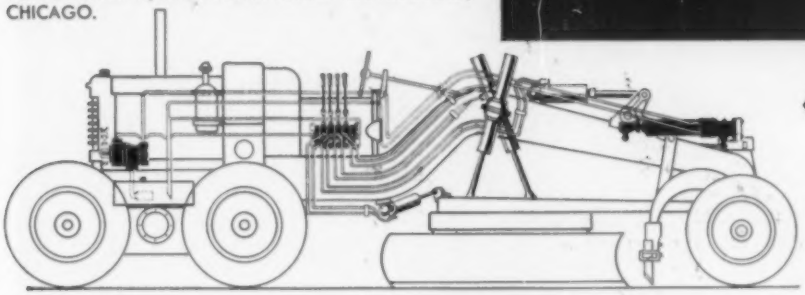
INLAND 4-WAY® SAFETY PLATE
INLAND STEEL COMPANY
38 South Dearborn Street • Chicago 3, Illinois
Sales Offices: Chicago • Milwaukee • St. Paul • Davenport
St. Louis • Kansas City • Indianapolis • Detroit • New York

"Nobody puts a fine painting in a dime-store frame." When you see a piece of construction equipment with Vickers Hydraulics, you know it is a "quality" machine throughout.

Vickers provides all the inherent advantages of hydraulics and MUCH MORE: (1) the benefits of a nation-wide and full-time field engineering and service organization of unequalled experience; (2) a complete line of equipment enables Vickers to take UNDIVIDED system responsibility thus eliminating any risk of incompatibility of hydraulic components; (3) a hydraulics school for free training of customers' maintenance personnel.

SEE VICKERS HYDRAULICS IN SIMULATED ACTION IN BOOTH 219 AT THE ROAD SHOW, JANUARY 28 TO FEBRUARY 2, AT INTERNATIONAL AMPHITHEATRE, CHICAGO.

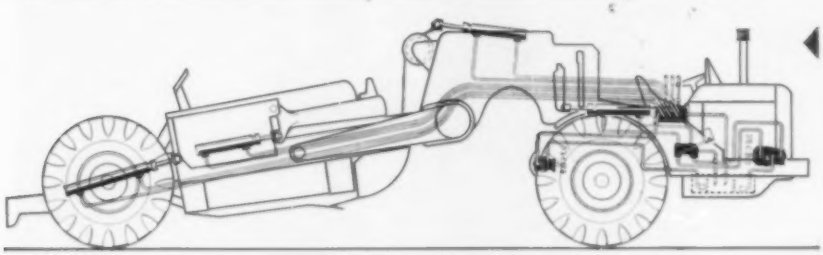
VICKERS HYDRAULICS *means* "QUALITY" CONSTRUCTION EQUIPMENT



Motor grader uses Vickers Hydraulics for:

- maximum blade utility
- accurate and effortless tool adjustment
- positioning scarifier
- convenience of control to operator

Hydraulic motor (not shown) rotates blade on circle. Hydraulic power steering is separate circuit. Central hydraulic system is applicable.



Scraper has VARIABLE rate hydraulic power steering provided by:

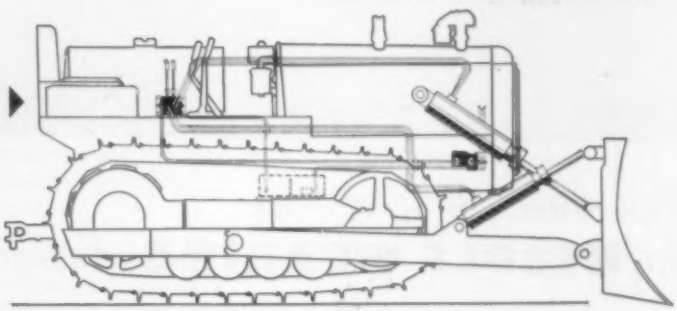
- Vickers Double Vane Pump
- Vickers Metering Control Valve
- Vickers Circuit-Splitting Unloading System
- Vickers Overload Relief Protection

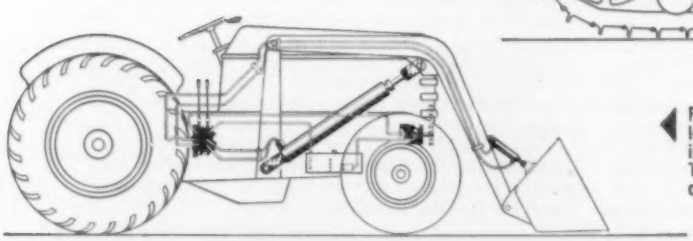
Vickers Single Vane Pump supplies power for:

- Fast actuation of bowl
- Fast apron manipulation
- Fast—Positive ejector action

More Work—Less Time—Minimum Maintenance.

Vickers Hydraulics provides fast lifting and angling of bulldozer blade along with exclusive "feathering" ability. Additional tractor attachments added later can be hydraulically controlled by simply adding sections to existing control valve thus eliminating necessity of mounting separate valves.





Fast, easy and dependable operation of front end loader utilizes Vickers Balanced Vane Pump (with inherent automatic wear compensation) and Vickers Two-Section Directional Control Valve. Note simplicity of installation.

SEE VICKERS BOOTH 219
A. R. B. A. ROAD SHOW • JAN. 28-FEB. 2
INTERNATIONAL AMPHITHEATRE, CHICAGO

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
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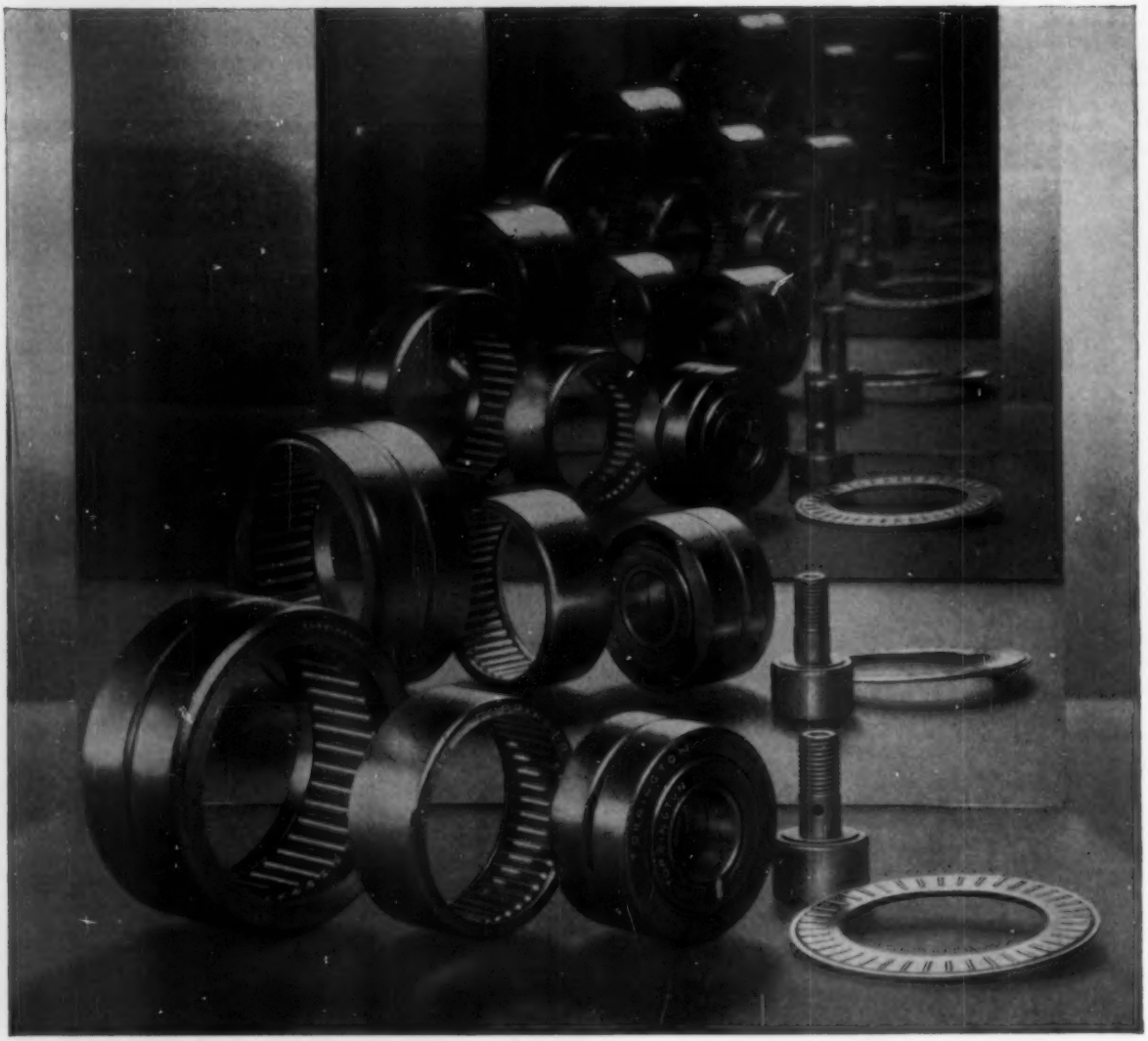
IN CANADA: Vickers-Sperry of Canada, Ltd., Toronto 7695

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921



For new perspectives in **NEEDLE BEARING** *design and performance*

. . . *look* to Torrington, pioneer in the development of every type of precision Needle Bearings.

Using carefully selected quality steels, and the most modern manufacturing methods, Torrington has developed a complete range of types and sizes of Needle Bearings for every use. There are special designs for rotation, for oscillation, even thrust applications! There are aircraft types, cam followers, and heavy duty types. Yet their unit cost is low, bringing anti-friction performance with economy.

Precision manufacture and the full complement of rollers that provides maximum radial capacity in minimum cross section make Torrington Needle Bearings top performers in the most rugged applications.

Little wonder their use has spread to countless applications in every field with outstanding success. Have you considered them for your product? Send for further information today.

THE TORRINGTON COMPANY
Torrington, Conn. • South Bend 21, Ind.

TORRINGTON BEARINGS

Needle • Spherical Roller • Tapered Roller • Cylindrical Roller • Ball • Needle Rollers

CONTROL FLUID FLOW

with Micrometer Accuracy

HANNA Flo-Set VALVES

For AIR, OIL and WATER operation to 250 p. s. i.
SIZES ¼" • ⅜" • ½" • ¾"
TEMPERATURES to 250°F

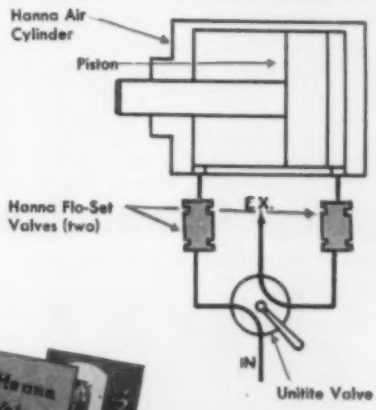
Hanna Flo-Set Valves are used to control cylinder piston speeds and operating speeds of many types of fluid actuated mechanisms. They are able to handle air, oil, water and many gases. When used with cylinders, these valves permit independent adjustments of forward and return piston speeds. The diagram at the right shows a typical circuit. Flo-Set Valves make the operation of air cylinders smoother and make cushioned cylinders more effective by building up essential back pressure.

Fluids pass unobstructed in the direction of the arrow on Hanna Flo-Set Valves. In the opposite direction, flow can be controlled from zero to full pipe capacity. One valve can be set to an infinite number of controlled flow positions. Once set, the position can be held by means of a locking collar. Established flow positions can be reset by using the micrometer graduations which accurately measure flow as a percent of full pipe capacity.

One revolution of the aluminum valve body will change the flow rate from zero to full capacity. No tools are necessary! In addition to the standard ¼", ⅜", ½" and ¾" sizes, there is a ¼" Jr. model, without micrometer graduations or locking collar, for light piping and tubing.

Typical Cylinder Circuit Using Hanna Flo-Set Speed Control Valves

Hanna engineers will gladly recommend circuits to help you with your applications.



Consult your classified telephone directory or Thomas' Register for your nearest Hanna representative. Write for Hanna Valve Catalog 254 and Flo-Set Valve Bulletin 253A.

Hanna Engineering Works

HYDRAULIC AND PNEUMATIC EQUIPMENT . . . CYLINDERS . . . VALVES . . . RIVETERS

1763 ELSTON AVENUE — CHICAGO 22, ILLINOIS

Designer's

Thymotrol* fhp adjustable-speed drives in full new line are more compact, cost less

A completely re-designed line of fractional-horsepower Thymotrol adjustable-speed drives—at new lower prices—is now offered by General Electric.

Thymotrol drives—comprising d-c drive motor, control panel, and control station—are applicable to conveyers, machine tools, and other small machines whose performance can be improved by adjustable speed. With a full range of ratings (economical half-wave units: 1/50 to ¾ hp; smooth operating full-wave units: ¼, ½, ½ hp) plus availability of a variety of optional performance features, you get exact matching of job requirements, pay only for as much drive as you need.

D-c drive motors provide outstanding performance on rectified power, supplying constant torque over the entire speed range. Open dripproof and totally enclosed constructions are standard, others are available.

Control panels electronically convert a-c to d-c power. They are housed in easy-to-install, NEMA Type 1 wall-mounted enclosures, with lift-off covers for easy maintenance.

20:1 speed range and close speed regulation increase machine's versatility, permitting its use on a variety of jobs.

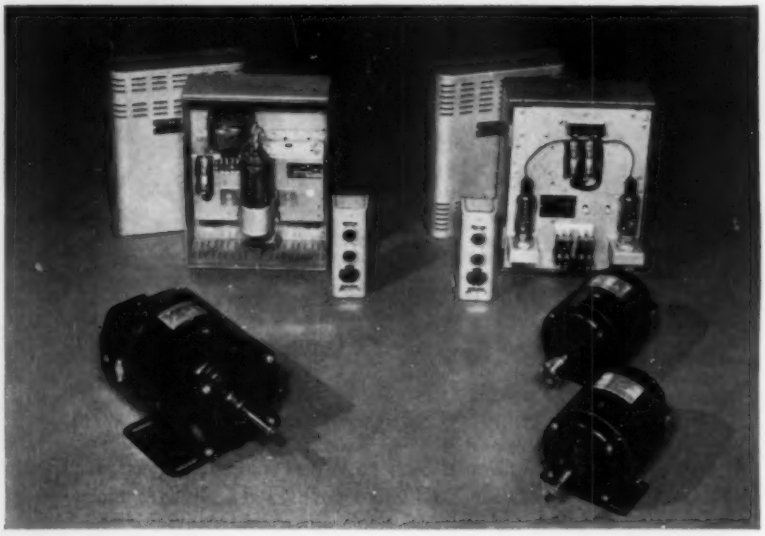
*Registered trade-mark of General Electric Co.

Printed circuitry contributes compactness and sturdiness, makes possible lower prices, faster delivery.

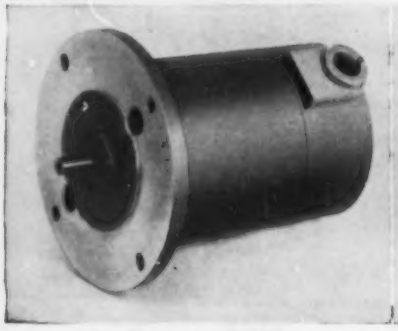
Dip soldering firmly secures panel board components to printed circuitry. Component replacement is fast, simple, requiring only a soldering iron and pliers.

Single-tube design of half-wave Thymotrol drives emphasizes the unit's extreme simplicity of construction.

Plug-in panel boards facilitate rapid servicing. Complete panel can be removed or installed in ten seconds—without disturbing customer wiring—permitting a high continuity of production. Write for GEA-6519.



Lightweight tachometer generators measure speed ranges from 100 to 5000 rpm



A-c tachometer generator.

D-c tachometer generator.

When your machine tool application calls for speed indication of moderate accuracy, select G.E.'s compact tachometer generators which are only $3\frac{5}{16}$ inches in diameter. Weighing less than four pounds, the versatile four-pole a-c tachometer generators feature totally enclosed construction and serve speed ranges from 400 to 5000 rpm.

Two-pole, d-c, ball-bearing tachometer generators provide accurate speed ranges from 100 to 5000 rpm. These units weigh less than six and one-half pounds and can be used as a signal source in a speed regulated drive scheme. Write for GEC-1405.

GENERAL ELECTRIC

Digest

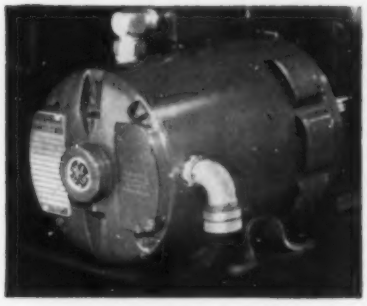
PRODUCT HIGHLIGHTS

Versatility of new KINAMATIC† d-c motors simplifies motor selection problems

New General Electric d-c Kinamatic motors can meet modern industrial needs by performing either as an individual motor drive or in regulating systems. Their versatility and flexibility permit a wide variety of both constant- and adjustable-speed applications used today for automatic processing. These versatile features help designers simplify motor-selection problems. ***Adjustable-speed*** by armature voltage control, field strength control, or combination of both, provides the speed, torque, horsepower required in almost any sequence. ***For constant horsepower,*** higher operating speeds are obtained through field strength adjustments. ***For lower speeds,*** the d-c Kinamatic motor can operate over wide speed ranges including speeds far below base, even stalled conditions. Ratings from 1 to 150 hp are included in the line. See GEA-6355.

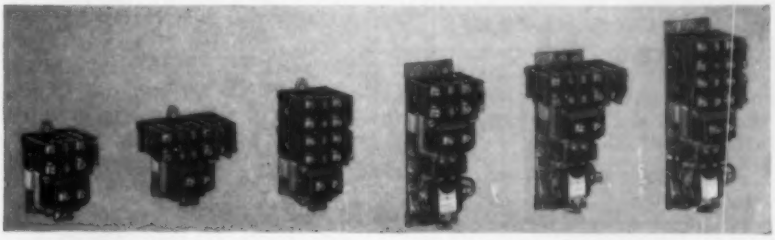
†*Trade-mark of General Electric Co.*

FHP machine tool motors factory lubricated for ten years



Special ball-bearing construction and new-type grease in G-E totally enclosed fan-cooled machine tool motors provide long, low-maintenance service and support heavy thrust loads. Sturdy welded-on base assures rigid mounting and accurate motor alignment; compactness simplifies assembly and design. These motors are rated ¼, ⅓, ½, ¾ horsepower in 60/50 cycles, 208–220/440, 220/380, 500 volts and are engineered to stand up under continuous start-stop service in heavy-duty industrial applications. See Bulletin GEC-1306.

New machine-tool relay family features long life, easy wiring



New General Electric machine-tool relays are now available with 2 to 8 poles, including a 6-in-line model with same mounting dimensions as the 4-pole form.

Relay contacts can be changed from normally open to normally closed without extra parts. Front-connected saddle-clamp terminals make wiring easy. Strongbox coils are protected against oil, moisture, and dust. Ratings are 10 amperes, 110–600 v, 25–60 cycles. See Bulletin GEA-6317.

General Electric Co., Apparatus Sales Division, Section C668-133, Schenectady 5, N. Y.

Please send me the following bulletins:

√ for reference purposes		× for immediate project	
☐GEA-6317	Control Devices	☐GEC-1306	Fhp Machine-tool Motors
☐GEA-6355	Kinamatic D-c Motors	☐GEC-1405	Tachometer Generators
☐GEA-6519	Fhp Thymotrol Drives		

Name ..... Company .....

City ..... State .....

RB&W FASTENER BRIEFS

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

Technical-ities

By John S. Davey

Bolts take greatest stress during wrenching

If a bolt doesn't fail when being wrenched up tight, it won't fail in service (assuming bolts and joint have been designed adequately for the loads).

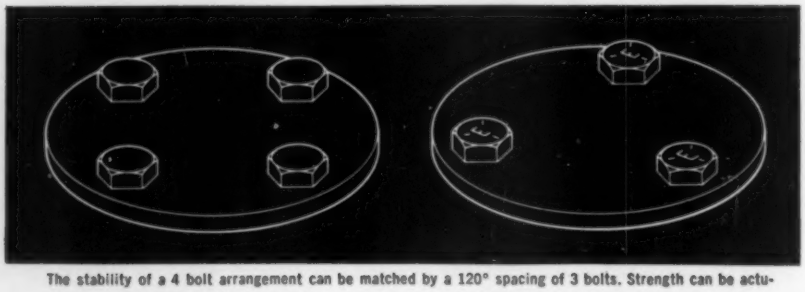
That's because two forces put stress on bolts (and cap screws) as they tighten: Tension due to bolt stretch; torsion due to friction. But only tension remains after wrenching. In a rigid joint, if this tension exceeds external forces, bolts will never experience any further strain, and will therefore not loosen or fail.

WHY SOME FAILURES?

Obviously, unusual unforeseen loads cause trouble. The instant they exceed residual tension, *they add* to the stress placed on the bolt and can cause *immediate* failure. Or they can cause loosening, leading to stress change, which in turn causes fatigue and failure. That's why you've got to torque bolts tight . . . and the tighter the better.

An exception: A flexible joint. With high cyclic loading, again loosening and fatigue cause trouble. Since you shouldn't tighten such a joint too much, sometimes the only remedy is to take out the flexible element and put in a rigid joint. (A metal to metal flange connection instead of a gasketed one, for example.)

Are you using more bolts than needed?



The stability of a 4 bolt arrangement can be matched by a 120° spacing of 3 bolts. Strength can be actually increased by using RB&W high carbon heat treated bolts (identified by "E" and three radial dashes).

NOBODY wants to use too few bolts or cap screws and risk failures. But using too many is not the best answer either. It means too many holes to drill, to fill — both costly.

RB&W offers some suggestions.

BALANCED BOLT PATTERN

By "rule of thumb," bolts are generally arranged symmetrically in a pattern of four. Yet three bolts 120° apart around a common center will prove just as stable, and save on assembly. With stability assured, the problem is then one of load capacity.

PRELOAD TO GET FULL CAPACITY

In checking size and number of bolts, calculate the stress and get rid of the excess. You have enough if you've allowed for usual factor of safety . . . *and the fasteners are tightened so that residual tension exceeds maximum external load anticipated.* If they are, you have safety. The bolts will *stay* tight, won't fatigue, won't fail.

With RB&W standard fasteners, engineers and production men can take quality, uniformity and dependability for granted — and can concentrate on the problem of proper application and assembly. For help or information on your specific product, write Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, N.Y.

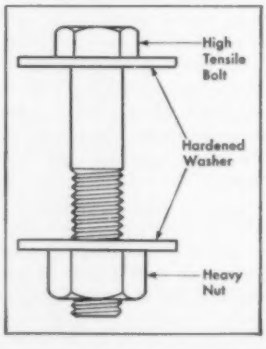
Plants at: Port Chester, N. Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

High strength bolts stop joint failure from vibration

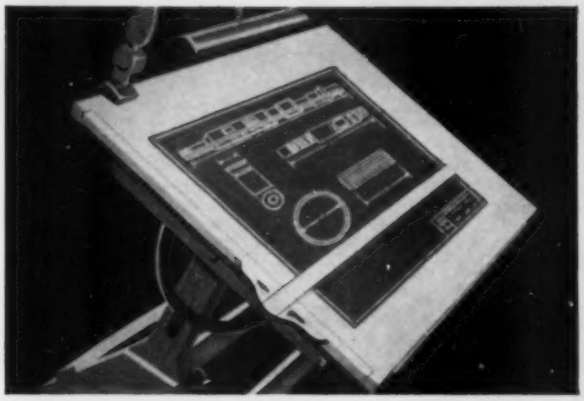
Shakeout equipment used by one company for unloading coal cars applied its vibration via a fabricated frame lowered onto the cars. This frame was originally riveted.

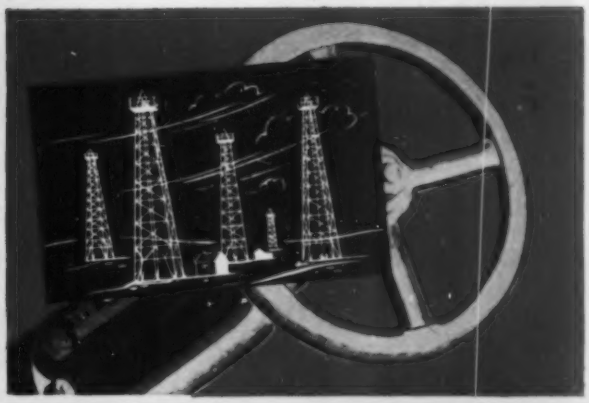
But it was a constant source of maintenance. About every 10 days, the frame had to be welded, loosened rivets replaced. Finally it was refastened with RB&W high tensile bolts and hardened washers. Maintenance now is *nil!*

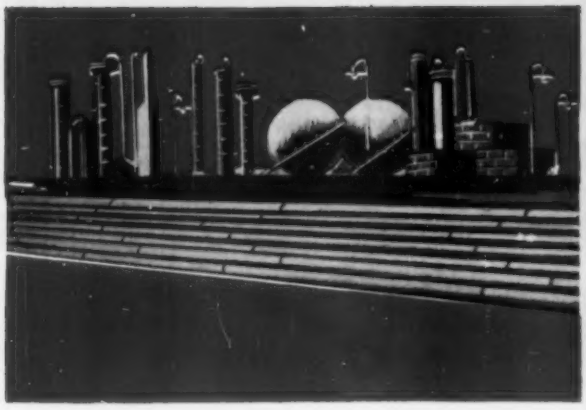
Proving again that high strength bolts make the strongest connection for the severest service.

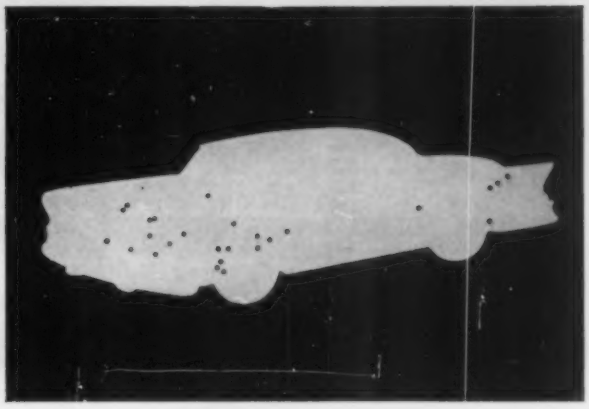


Naugatuck Paracrils









...oil-resistant rubbers for all critical applications

In every industry, Naugatuck's family of superior oil-resistant rubbers is bound to bring longer service life under the most critical conditions. Graded to provide specific property values, the family of PARACRILS® provides:

- The most oil-resistant rubber available
- The best balance between oil-resistance and low-temperature flexibility.
- The best processing characteristics
- The most tightly-controlled product specifications
- Excellent resistance to aging at elevated temperatures
- High abrasion resistance
- The best resistance to air and gas permeability

If your rubber or rubber-like products require high oil resistance it will profit you to investigate Naugatuck's PARACRILS Why not write to us on your company letterhead TODAY?

Naugatuck Chemical

Division of United States Rubber Company
Naugatuck, Connecticut

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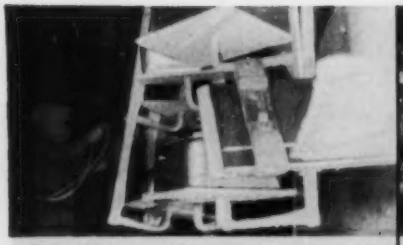


Reynolds can paint entire parts a solid color, mask and paint or do paint filling in combination with mechanical finishing to supply practically any desired texture or highlighting effect.

Part of a battery of new high speed buffing equipment available at Reynolds. Scratch-brushing, satin finishing, highlighting, embossing and other mechanical finishes are also available.

Alodine system at Reynolds is adaptable to immersion, spray or brush type finishing. Etching, brightening and other chemical finish treatments are also available at Reynolds.

for greater design freedom and finer "finished" aluminum products ... use the new, vastly expanded

REYNOLDS FINISHING FACILITIES

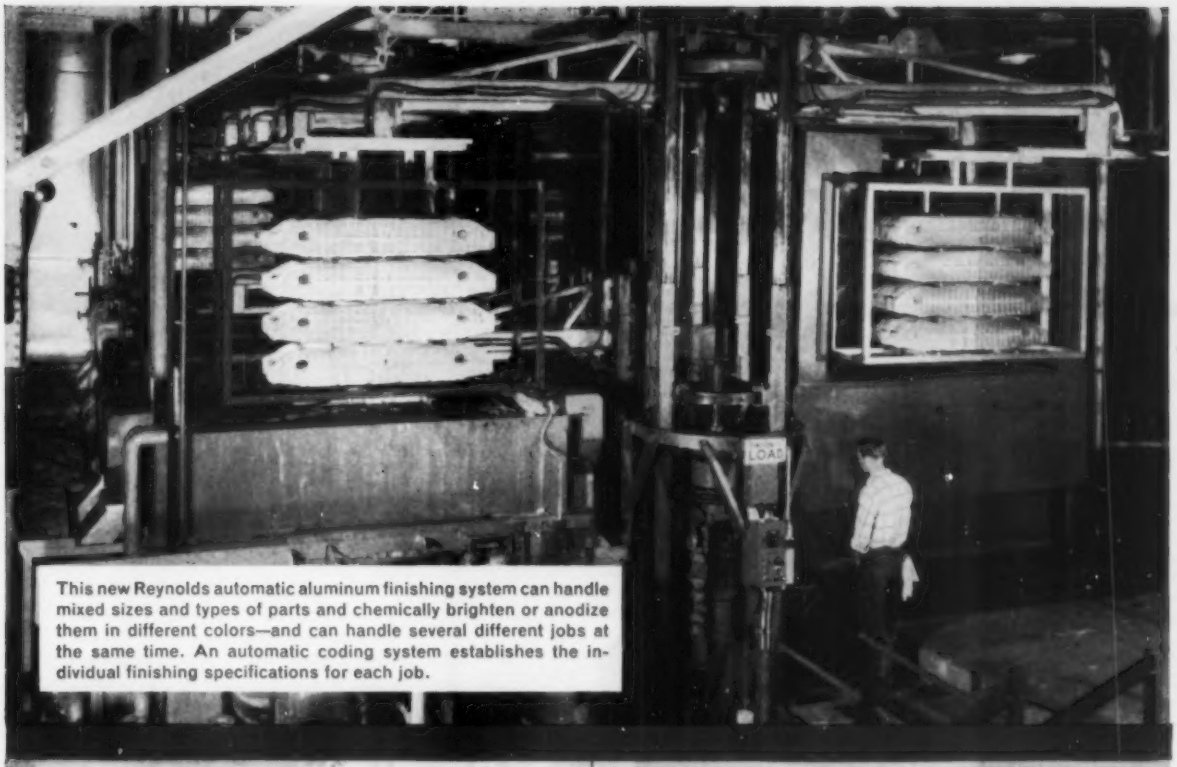
For the magic touch of gleaming clear and color anodized finishes—and for many types of mechanical, chemical and paint film finishes—you can depend on finishes from Reynolds to add sales appeal and value to the aluminum products you design.

Reynolds multi-million dollar investment in finishing equipment—some of this equipment illustrated on these pages—assures you the finest aluminum finishing facilities available anywhere. These recently expanded facilities permit new and greater flexibility in your design thinking. And these facilities are backed by Reynolds years of technical experience with practically every finishing process and technique applicable to aluminum plus Reynolds quality control from mine to finished part.

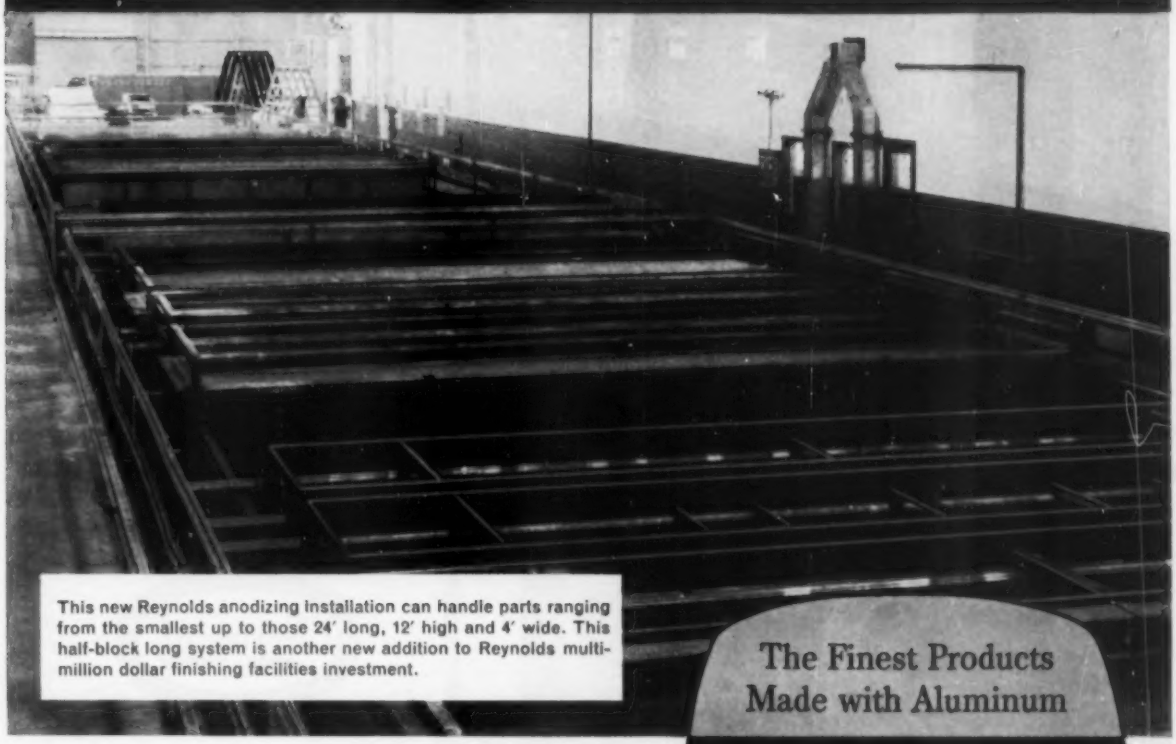
For full details on the finishing and fabricating facilities available, call the Reynolds Office listed under "Aluminum" in your classified telephone directory or write *Reynolds Aluminum Fabricating Service, 2051 South Ninth Street, Louisville 1, Ky.*

See "CIRCUS BOY", Reynolds new dramatic series, Sundays on NBC-TV

REYNOLDS ALUMINUM FABRICATING SERVICE



This new Reynolds automatic aluminum finishing system can handle mixed sizes and types of parts and chemically brighten or anodize them in different colors—and can handle several different jobs at the same time. An automatic coding system establishes the individual finishing specifications for each job.



This new Reynolds anodizing installation can handle parts ranging from the smallest up to those 24′ long, 12′ high and 4′ wide. This half-block long system is another new addition to Reynolds multi-million dollar finishing facilities investment.

The Finest Products Made with Aluminum

are made with

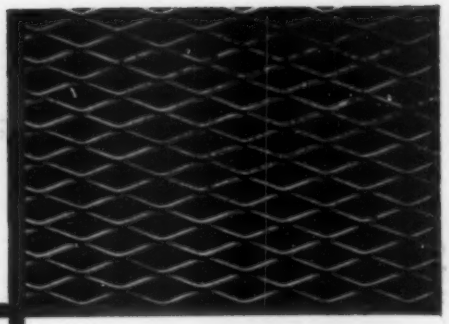
REYNOLDS ALUMINUM

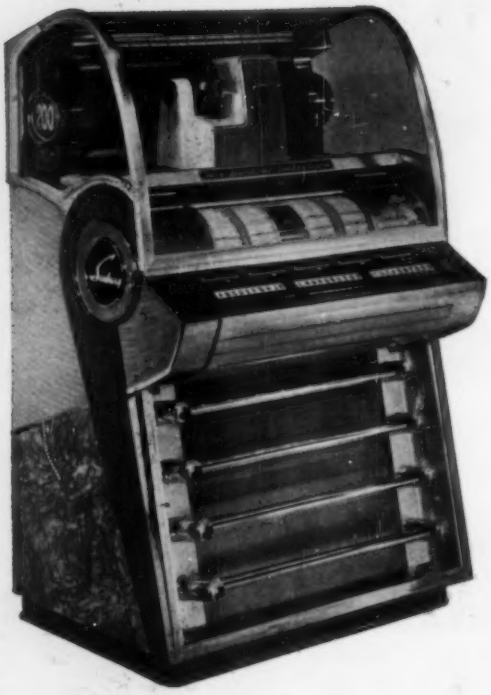
BLANKING · BRAZING · DRAWING · EMBOSSING

FINISHING · FORMING · RIVETING

ROLL SHAPING · TUBE BENDING · WELDING

Handsome, functional MINIMESH ⇨ makes good products better





Minimesh grille protects speaker, transmits sound, adds beauty in new coin-operated phonograph by J. P. Seeburg Corp., Chicago.

Because it combines beauty and utility — at low cost, Penmetal Minimesh is widely used for decorative purposes and for guards or grilles on stoves, heaters, radios, phonographs, etc. Three famous products, which have been improved with Minimesh, are shown.

Minimesh is small mesh ($^3/_{16}$") expanded metal, and like the larger meshes, is sheet metal which has been slit and expanded up to five times its original width. 80% lighter than solid sheet of the same dimensions, the diamond truss pattern adds rigidity and strength.

The openings in Minimesh permit passage of light, heat, air and sound. Comes in standard or flattened form. Can be cut, shaped or welded to suit design requirements.

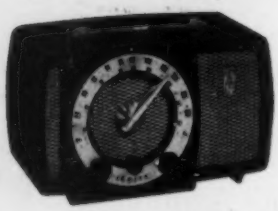
Put Minimesh to work for you. Write for new catalog 510-EM, which gives sizes, weights and dimensions.

PENN METAL COMPANY, INC.

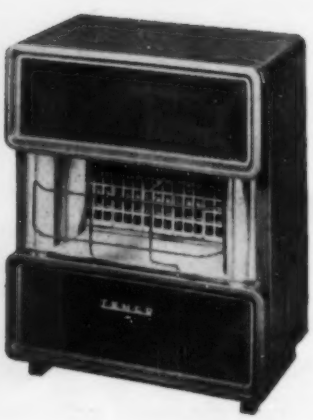
General Sales Office: 40 Control Street, Boston 9, Mass.

Plant: Parkersburg, W. Va.

District Sales Offices: Boston, New York Philadelphia, Pittsburgh, Chicago, Detroit, St. Louis, Dallas, Little Rock, Seattle, San Francisco, Los Angeles, Parkersburg



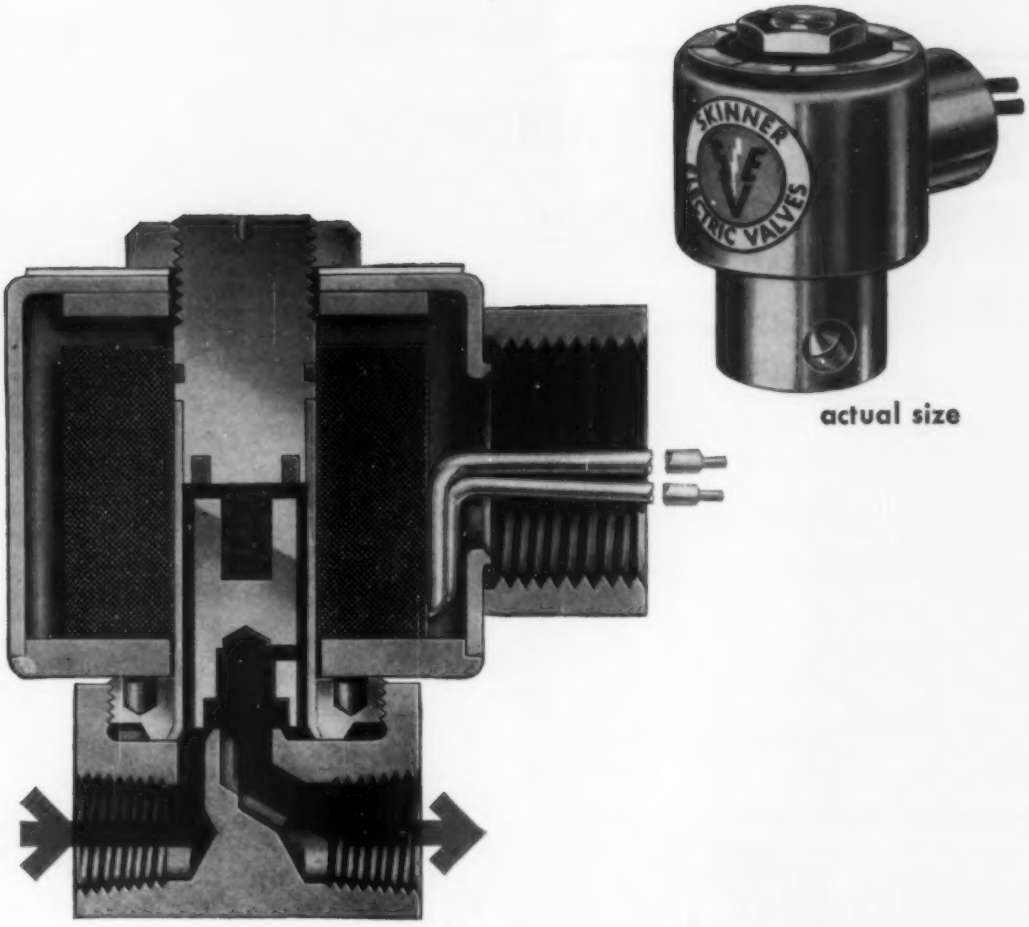
ABOVE — Zenith Radio Corp., Chicago, incorporates extensive Minimesh grillework in this radio set.



RIGHT — Gas heater by Temco, Inc., Nashville, Tenn. — one in a famous line recently redesigned with Minimesh to bring modern styling to the gas heating field. Open mesh grilles deliver heat.

METAL MARK Penmetal 1869 OF QUALITY

PM-100



actual size

New C-series solenoid valve offers recognized "Skinner Quality" at low cost

This is a faithful reproduction—in miniature—of the time-tested, 2-way, normally closed Skinner V5 except that the body is made of brass.

This new, compact Skinner valve weighs only 12 ounces, yet it's rugged enough to last millions of cycles on most applications.

This new valve has orifices from 5/32″ to 7/64″, with pressures ranging from 60 to 130 psi. Pipe size is 1/8″ NPT. It is a packless, direct-acting valve with only two moving parts. And it's absolutely bubbletight—even on vacuum. This C-Series Skinner valve is fail-proof, too—a built-in spring return assures positive closing; thus it can be mounted in any position and is ideal for direct-line mounting.

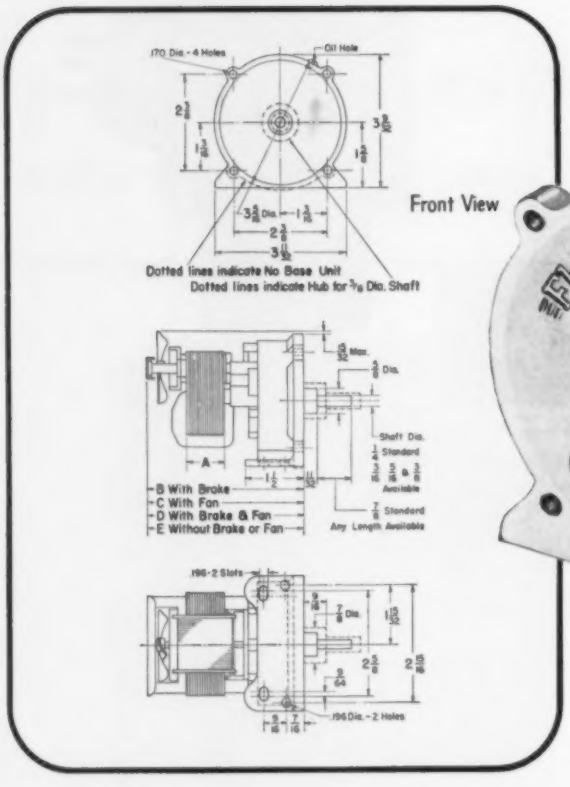
You'll find this new valve, with its recognized "Skinner Quality," the perfect low-cost answer to a wide range of flow control problems. It works efficiently with air, water, oils, gasoline and many other media. Typical applications include: automotive fuel systems, welding equipment, vending machines, lubricating devices, spraying equipment, air horns, water softeners, humidifiers and instrumentation.

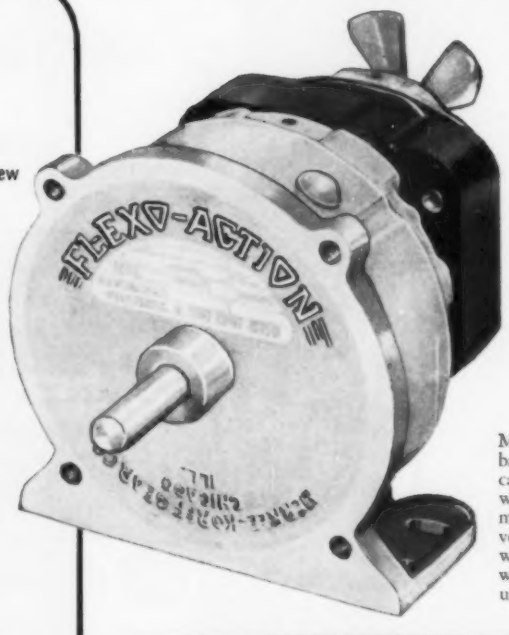
Our Bulletin D11.1 contains complete information on this valve—flow curves, optional features, dimensions, electrical data, etc. We will be happy to send you a copy on request.

SKINNER · ELECTRIC VALVES ·

SKINNER ELECTRIC VALVE DIVISION NEW BRITAIN CONNECTICUT

THE SKINNER CHUCK COMPANY





Model SG25 with base case. This unit can also be furnished with no base for face mounting, with inverted base, or side wall mounting, or with shaft vertically upward.

Stator Thickness and Corresponding Length				
A	B	C	D	E
9/16	3 1/8	3 1/4	3 9/16	2 7/8
1 5/16	3 1/2	3 7/8	3 1 5/16	3 1/4
1 1/2	4 7/16	4 3/4	4 1 5/16	4 1/4

How To Buy the Right Geared Motor for Your Job

Measure the speed and torque required when possible. If torque can't be measured make a realistic estimate. Buying a motor that is too strong can be just as harmful as buying one that is too weak.

Be sure to specify direction of rotation, if uni-directional, or reversing if required. Will the motor operate continuously or is the duty cycle intermittent? Specify the type motor required for the job—whether induction or synchronous, AC, DC or universal.

Experienced Merkle-Korff application engineers can assist you in choosing the right unit for the job. They will recommend a fractional horsepower geared motor with an ample margin of safety to meet overload or low voltage conditions.

Merkle-Korff has been building a product of proven quality for years and can deliver motors *on time* to fit your production schedule.

A typical torque table is shown. This table shows no-load speeds for uni-directional shaded pole induction motors. The loads are the maximum under which the motor will start and operate continuously without over-load. The speeds shown are those commonly used. If the maximum rated torque is required at speeds greater than shown, modifications can usually be made. Units can be furnished at speeds as low as 1 RPH or slower.

Merkle-Korff builds a varied line of fractional horsepower geared motors. For detailed dimension drawings, mounting styles and torque tables of the complete line, write for engineering data sheet PE2.

TORQUE TABLE - LB. IN.
MODEL SG-25

	stator thickness and torque		
rpm	9/16"	1 5/16"	1 1/2"
300	1.2	1.5	3.0
150	2.3	3.0	6.0
100	3.5	4.5	9.0
60	6.0	7.5	15.0
45	6.6	9.0	17.0
30	10.0	13.0	26.0
25	12.0	16.0	30.0*
20	15.0	20.0	"
15	20.0	26.0	"
12	25.0	30.0*	"
10	30.0	"	"

* At these speeds and lower the units will deliver more torque than is shown on the tables. The output shaft should not be loaded above the value shown on the table. This is the rated capacity of the gear case.

MERKLE-KORFF GEAR CO.

219 NORTH MORGAN STREET • CHICAGO 7 • ILLINOIS

JUST PUBLISHED!

New 24-page brochure gives complete engineering data

Here's the story of fatigue-proof™ steel bars

MADE BY THE e.t.d. PROCESS

Elevated Temperature Drawing

*a **new** material—made by*

*a **new** process—with*

*a **new** combination of properties*

High Strength
Free Machining
Uniformity
Fatigue Resistance
Wear Resistance
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Plus Accuracy, Smooth Finish, and Straightness

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City_____ Zone____ State_____

Potter & Brumfield *engineering is in this picture*

Which P&B relay would you specify to CONTROL AN ELECTRONIC OVEN?

PR Series

MS Series

MR Series

New electronic ovens—the kind which cook an 18-pound turkey in an hour and a half, a large beef roast in 30 minutes, or bake potatoes in 4 minutes—require heavy duty, fast-acting relays designed for high voltage switching. Long, trouble-free service is essential and U/L approval is a must.

The relay specified by one top manufacturer to fill this bill is P&B's PR 11, specially adapted to our customer's specifications. P&B engineers are old hands at adapting basic relay types to highly specialized uses. Twenty-five busy years of relay designing, engineering and manufacturing at P&B have built an unrivaled backlog of information and skill which is yours to command.

ENGINEERING DATA

SERIES: PR Heavy Duty.

CONTACTS: Max. DPDT. 5/16" dia. silver, 13 amps. at 115 V., 60 cycle, non-inductive. 6.5 amps. at 230 V. 60 cycle, non-inductive.

VOLTAGE RANGE: 6 to 110 V. DC. 6 to 230 V. AC.

COIL RESISTANCE: 63800 ohm max. DC.

TEMPERATURE RANGE: DC, -45° to 85° C. AC, -45° to 55° C.

PULL-IN: DC, 75% nominal. AC, 78% nominal.

TERMINALS: Heavy duty screw type. Adaptable for printed circuits or plug-in.

BASE: Molded phenolic or metal.

MOUNTING: (2) 3/16" dia. holes on 1⅞" centers.

DIMENSIONS: 2½" W. x 3⅜" L. x 2½" H.

P&B RELAYS AVAILABLE AT MORE THAN 500 DISTRIBUTORS IN ALL PRINCIPAL CITIES

Potter & Brumfield, inc. PRINCETON, INDIANA

Subsidiary of AMERICAN MACHINE & FOUNDRY COMPANY Manufacturing Divisions also in Franklin, Ky. and Laconia, N. H.

NEW, COMPACT Century 48-FRAME Fractional HP MOTORS

INDUSTRIAL QUALITY for all applications

take less space...
weigh less...
perform better!

ROTOR

Rotor bars, end rings, and fans integrally pressure-cast of virgin aluminum. Rotors dynamically balanced to very close limits; meet strict quiet-motor requirements.

INSULATION

Heavy vinyl acetal insulated wire, tough mechanically, thermally, and dielectrically, has excellent moisture resistance, highest uniformity. Stator core slots lined with cells of DuPont Mylar bonded to all-rag electrical paper.

BEARINGS

Sleeve: pressed into place in bracket which has been bored true in single set-up operation. Finish boring operation assures proper bearing surface and concentricity. *Ball:* single-shielded, precision fitted in brackets.

LUBRICATION

Sleeve bearing type: wool yarn wicking provides constant oil supply to oil groove. Inner sump cup retains excess oil which is tapped by felt wicks extending into the wool yarn. *Ball bearing type:* standard construction permits re-greasing.

GOVERNOR and SWITCH

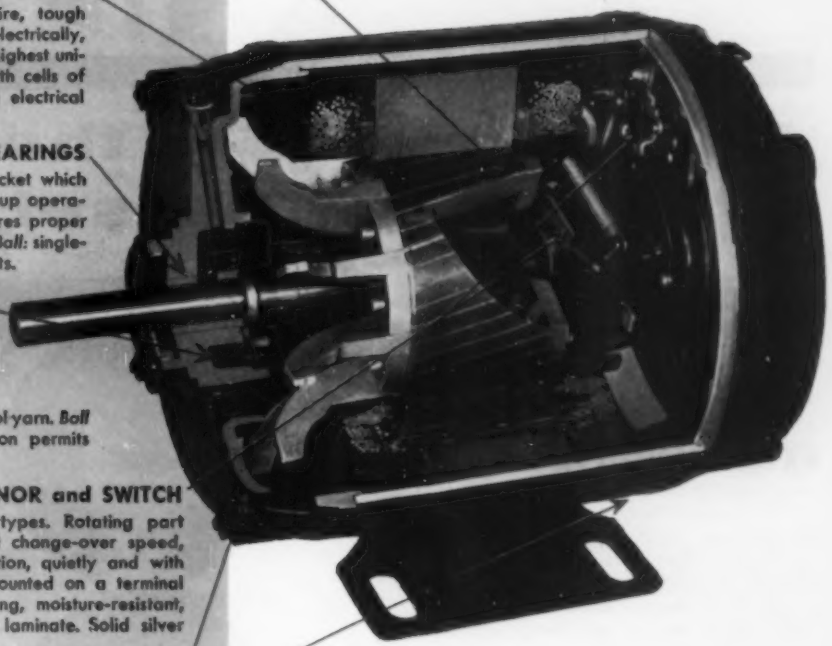
For capacitor and split phase types. Rotating part securely press-fitted to shaft. At change-over speed, governor operates with snap action, quietly and with no flutter. Stationary switch is mounted on a terminal plate; plate is GLASTIC, a strong, moisture-resistant, arc-resistant glass-filled polyester laminate. Solid silver contacts are used.

BEARING BRACKETS

Pressure cast in special aluminum casting alloy. Stress relieved for permanent stability. Strong internal ribbing for strength, and smooth outside surface.

FRAME

Stator frame rings formed of one-piece heavy rolled steel. No frame openings; windings fully protected. Rabbet fit faced and bored true to provide proper alignment of bracket and a concentric air gap. Heavy formed steel feet welded to frame ring.



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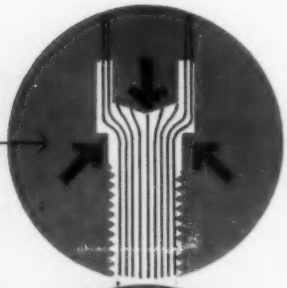
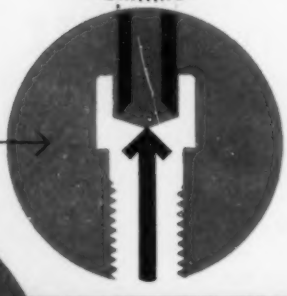


Metal fibers stay intact for greatest strength. No drilling, cutting, broaching to weaken socket walls.

NO WALL TAPER IN HOLO-KROME SOCKETS!



Hex key bears evenly against smooth untapered walls. The results: easier, faster assembly . . . longer key life . . . fewer damaged screws!

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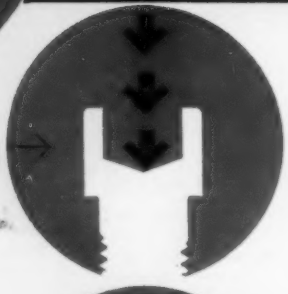
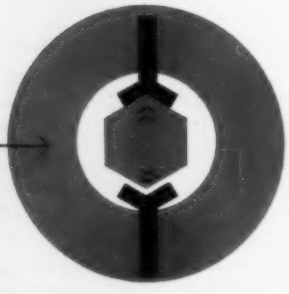


Sockets are formed deep enough for hex key to get a firm, solid bite . . . yet scientifically proportioned to give maximum strength to the screw head.

H-K's SHARP SOCKET CORNERS RESIST REAMING!



The hex key fits better, bears evenly under pressure, gets a solid grip for positive fastening.

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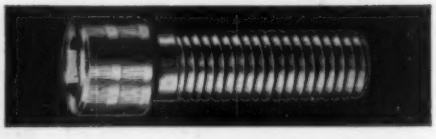

DESIGNING WITH ALUMINUM

This is one of a series of information sheets which discuss the properties of aluminum and its alloys with relation to design. Extra or missing copies of the series supplied on request. Address: Advertising Dept., Kaiser Aluminum & Chemical Sales, Inc., 1924 Broadway, Oakland 12, California.

NO. 23

JOINING ALUMINUM TO COPPER AND STEEL

When aluminum must be joined to other metals, particularly copper or steel, virtually any metallic bonding process may be used. The most desirable process for a particular application depends on considerations of cost, speed of production or service requirements of the finished joints.

Of course, in all construction involving dissimilar metals joined together or in close proximity, care should be taken to minimize the possibility of galvanic corrosion.

Small Electrical Connections

The electrical industry has found that small connections between aluminum and copper can be made using ordinary soldering iron techniques and common solders selected for the specific application. In simple soldered joints such as these, tin and tin-zinc solders are most commonly used.

One automotive manufacturer uses a resistance soldering technique for joining aluminum to steel in its car's electrical system. An aluminum wire is staked in a slot cut into the top of the steel stud to which it is to be connected. Flux is applied to the contact area and the head of the stud heated by two copper electrodes located on opposite sides of the joint. A pure tin solder is then applied manually to the joint area. A subsequent water quench also serves to remove flux residues.

Heaters and Engine Radiators

In the automotive field there has been an increasing interest in the use of soldering for joining brass and aluminum parts in heaters and engine radiators.

The cellular type of construction used in heater cores lends itself well to dip soldering techniques. The assembled core may be dipped in a reaction flux before furnace heating to 600F. The face of the assembly is then dipped ⅛ inch into a 750F solder bath. By capillary action, the solder rises half way through the thickness of the core. After the back of the assembly is dipped, the core is cooled and washed with water.

The tube-fin and cellular-tubular radiator constructions can be assembled by furnace soldering (see figure 1). In this method, the brass tubes are coated with a 20% tin-80% lead solder before the core is assembled. After assembly, the cores are fluxed and heated for two to four minutes in a 750F furnace. Flux residues are then removed by a water wash.

In both the dip soldering and the furnace soldering methods, conventional procedures used in making copper radiators are followed. For heater cores and engine radiators, tin-zinc base solders are finding the most favorable acceptance.

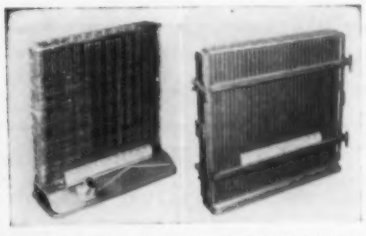

FIGURE 1. Furnace soldered aluminum-brass radiators. Left, aluminum fins, brass tubes. Right, aluminum cells, brass tubes.

Electrical Conductor and Connectors

Sound, strong joints are now being made by pressure welding single strands of aluminum to copper wire. On wire up to about ⅛ inch in diameter, this is done with hand tools resembling wire cutters. Very much larger sections are also joined by pressure welding, using larger power operated equipment.

FIGURE 2. The ALCUnector consists of elongated aluminum and copper cups whose bases are butt welded together as shown in this cross section. A dielectric ball is then molded around the joint to minimize galvanic action between the two metals.

A recent Kaiser Aluminum research development uses either pressure or flash butt welding to join the bases of elongated aluminum and copper cups. The ALCUnector,* as this new device is called, is believed to be the most corrosion resistant and efficient connector yet devised for joining aluminum and copper electrical conductors.

Made in a wide range of sizes, the ALCUnector is compact, easy to use and as strong as the conductors it joins. Its design is the reason for its success, and the welded joint is an important part of the design. The ALCUnector structure and method of making same are protected by patent rights of Kaiser Aluminum & Chemical Corporation.

Bus Bar Connections

The use of aluminum electrical bus is becoming standard in production plants and other large installations that consume large quantities of electricity. In these heavy load electrical systems, it is frequently necessary to connect aluminum bus to copper or steel. Whenever there are extremes or moderate fluctuations in temperature, bolted connections may be unsatisfactory.

To solve this problem, special joint designs and welding techniques have been devised by Kaiser Aluminum welding research engineers. Figure 3 shows how some of these welded connections are designed. The welds must be made with a moderate amount of care.

There are several ways by which these joints can be made, but one of the

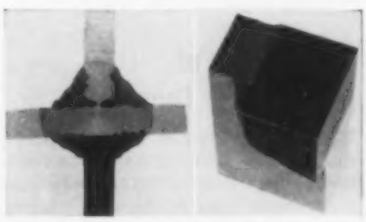

FIGURE 3. Aluminum is frequently joined to copper or steel in electrical bus systems. Left, copper is braze-welded to aluminum in a double Tee joint. Right, aluminum and steel are braze-welded. In neither case is the copper or steel melted during joining.

*A registered trademark of Kaiser Aluminum & Chemical Corp.

best methods is a braze-welding technique.

In the braze-welding of aluminum to copper by the consumable electrode, inert gas welding technique, the copper is first "tinned" with a coating of silver solder in the joint area. This silver solder layer is applied to prevent the formation of a brittle aluminum-copper alloy at the joint. The arc is then directed on the aluminum in the joint area in such a way that it does not bear on the solder-coated copper.

When joining aluminum and steel, a zinc-aluminum solder should be used for coating the steel in much the same way that silver solder is used on copper. Or it may be applied by a hot dip or galvanizing technique. The joint is then gas welded or brazed.

In either type of joint, keys cut in the copper or steel help to add strength to the joint. This type of joint eliminates the problem of differences in thermal expansion. It has given excellent service at operating temperatures up to 500F. The braze-weld joint and method of making same described herein are protected by Kaiser Aluminum & Chemical Corporation patent rights.

A GENERAL GUIDE FOR SOLDERING ALUMINUM TO COPPER AND STEEL

Application	Soldering Method	How Solder is Applied	Solder Used	Type of Flux Used
joining aluminum cable to copper lugs	dip soldering torch	by solder bath manually fed	30 tin–70 zinc 60 tin–40 zinc	zinc chloride type zinc chloride type
intricate assemblies (e.g., brass tube aluminum fin automotive radiators)	furnace	tubes precoated with solder	30 tin–70 zinc	zinc chloride type or hydrazine type
joining steel tubing to aluminum sheet (e.g., refrigerator evaporator plates)	furnace	tubes precoated with solder	95 zinc–5 aluminum	zinc chloride type
joining aluminum generator field coils to cadmium coated steel pins	resistance	manually fed	pure tin	organic boron trifluoride type
joining aluminum to zinc castings	torch	manually fed	82.5 cadmium–17.5 zinc	zinc chloride type
thin sections (e.g., aluminum pigtails to copper tabs)	iron	manually fed or sections previously "coated" with the solder	34 tin–63 lead–3 zinc	zinc chloride type or organic boron trifluoride type

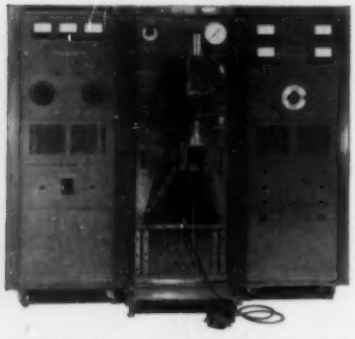

FIGURE 4. Ultrasonic welding units look much the same as spot and pressure welding equipment. However, the principle is entirely new to welding and is expected to find wide use in the future.

Thin Sections of Aluminum and Copper

Ultrasonic welding is a new technique that will undoubtedly find wide use in the joining of thin sheets of aluminum and copper. This process, effective on sheet up to 0.040 inches thick, uses ultrasonic energy to break up the oxide film on the metal surfaces being joined. A small amount of pressure then completes the weld.

In this type of welding there is no "heat-affected zone" flanking the joint, and the original tempers of the metals are retained.

These are but a few of the many applications in which aluminum is being joined metallically to copper or steel. For further information or assistance in techniques for joining these metals in your own applications, take advantage of the wide design experience offered by Kaiser Aluminum engineers. Their information or advisory service is available, upon request and without obligation, to any manufacturer interested in these metal joining processes.

Contact the Kaiser Aluminum sales office or distributor listed in your telephone directory. Kaiser Aluminum & Chemical Sales, Inc., *General Sales Office*, Palmolive Bldg., Chicago 11, Illinois; *Executive Office*, Kaiser Bldg., Oakland 12, California.

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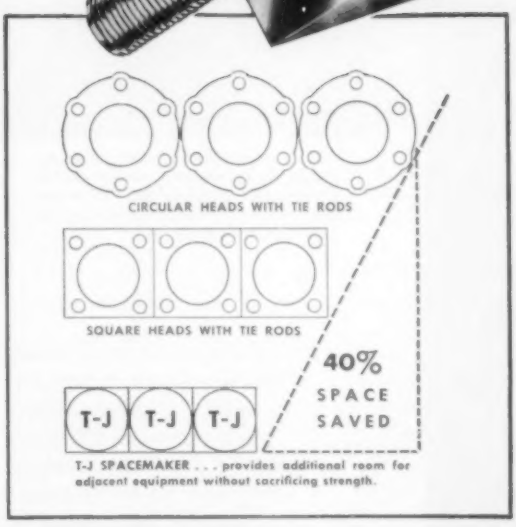
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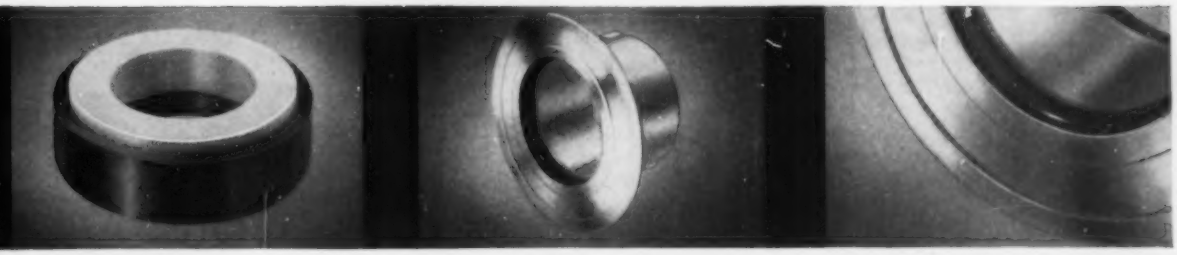


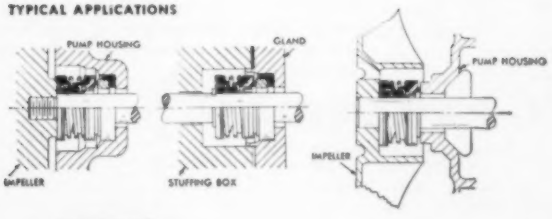
Stationary Seat of finest Ceramic is mounted in a molded cup-shaped vibration ring. Its sealing surface is precisely lapped for perfect contact with the carbon seal ring . . . perfectly matched for positive sealing.

Costly Two-piece Shell Construction. Shell rolls over a retainer ring which holds "O" Ring (static seal) in place and also provides a metal surface which gives you an exact mounting position. No danger of incorrect mounting due to improperly located static seal.

Static "O" Ring in Groove permits mounting seal from either direction without disturbing position in shell. Withstands higher pressures (100 psi.) and permits tighter fits than square shaped rings.

Roll Type Bellows provides greater travel than "V" type bellows.

TYPICAL APPLICATIONS



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NEW FROM FAIRBANKS-MORSE

SURE-FIRE PUSHBUTTON STARTS FOR SMALL GASOLINE ENGINES

Muscles are going out of style for starting small gasoline engines. New pushbutton-actuated electric starters being introduced by Fairbanks-Morse do the job much better.

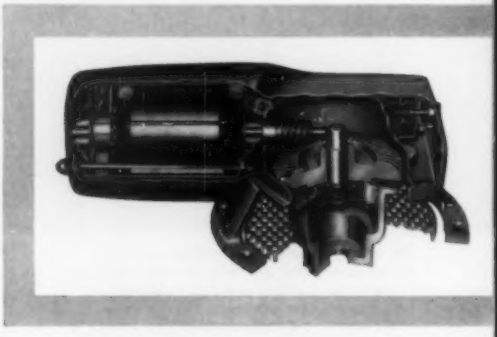
You don't have to redesign your gasoline engine to use the starter. A Fairbanks-Morse starter operated by either a 12-volt battery or 110-volt a-c power fits right on the same mounting as a conventional rewind starter.

Battery-operated Fairbanks-Morse starters give you added freedom of operation — particularly with mobile units that often require starting at a distance from an a-c power source. Also — having a battery mounted right on the engine opens the field for advanced design ideas. Other power accessories, impractical until now, can be added readily to a battery-equipped engine.

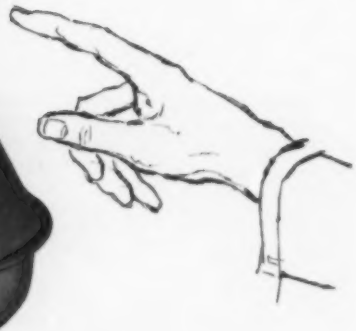
A charger that brings the battery up to full charge by being plugged into a 110-volt a-c outlet overnight keeps the starter ready to go at all times.

Direct drive without requiring a chain is another major feature of the Fairbanks-Morse electric starter. Use of Spiroid® gearing in the starter drive not only makes the drive compact but gives it the ability to withstand shock loads and assures virtually trouble-free operation.

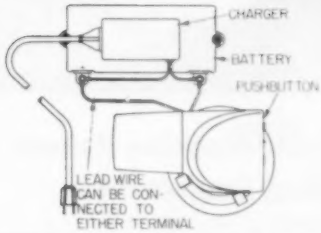
- **STREAMLINED** for Eye Appeal
- **EASY TO MOUNT** without Engine Redesign. Replaces conventional starter
- **DIRECT DRIVE** — No Chain Required
- **COMPACT** with Reliability Proved by Extensive Field Tests

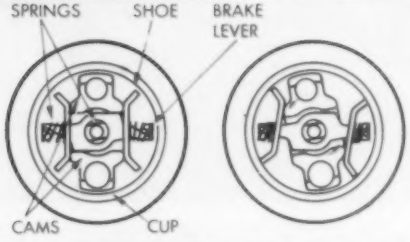


Cutaway of starter demonstrates ease with which the new Fairbanks-Morse unit fits into the same mounting location as a conventional rewind starter. Compact gearing contributes both to style and dependability of the new Fairbanks-Morse starter.



Style, compactness, and rugged performance are features of the new Fairbanks-Morse pushbutton starter. Gear-driven start instead of the old-fashioned chain assures quick, positive performance.





Starter, battery, and charger are combined in a neat package by Fairbanks-Morse. Considerable flexibility is possible in arranging components to meet needs of any gasoline-powered engine. The battery makes use of other power accessories practical.

Rotor assembly of rugged Fairbanks-Morse unit. Rotation forces cam-actuated special alloy shoes outward until they grip the inner wall of the cup as shown in sketch. Being spring-loaded, shoes disengage instantly when start button is released.

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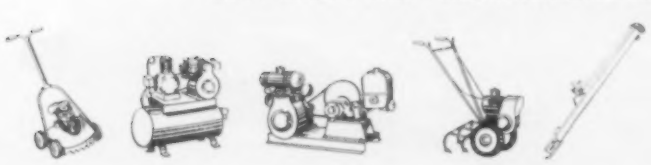

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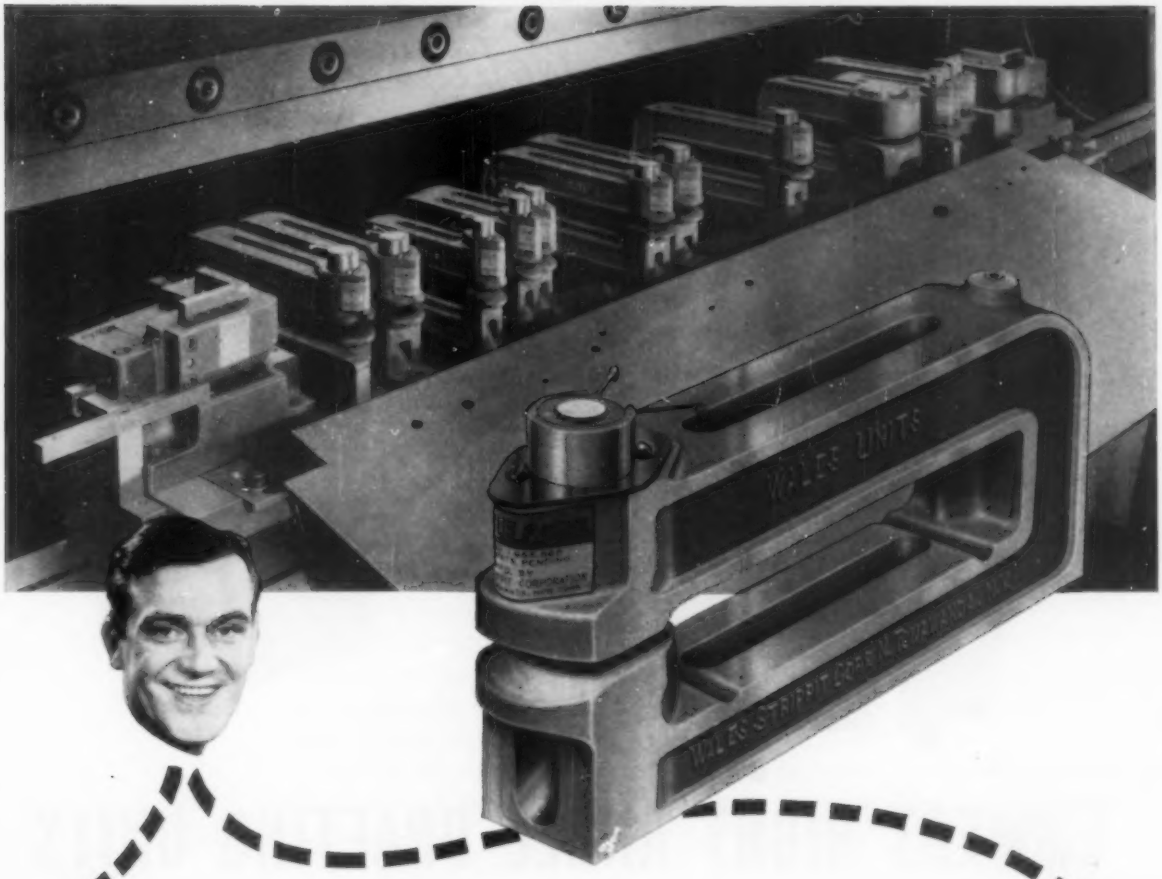

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Perspectives

IN DESIGN AND DEVELOPMENT

WHAT'S AHEAD IN BUSINESS FOR 1957?

The news is good. The significant points brought out in a preliminary survey of Business Plans for New Plants and Equipment, conducted by the McGraw-Hill Department of Economics during November and early December, show that:

- Business capital expenditures are heading for stability at a high level. Although this is the biggest and longest capital spending boom on record, no downturn is yet in sight.
- For 1957, business now plans to increase spending 11 per cent, compared with an increase of 21 per cent in 1956. Plans for new plants and equipment total $40.2-billion for all business.
- For 1958, about two-thirds of the companies surveyed plan to maintain or increase spending from the 1957 level. Only 30 per cent expect a decline.
- Business expects the prices paid for new plants and equipment to be about 6 per cent higher in 1957 than in 1956. This is an average.
- Construction difficulties, and delays in the delivery of equipment have held up some of the planned 1956 expenditures until 1957.
- Neither the elections nor the Suez crisis have had any significant effect on plans to date. Only 3 per cent of the companies surveyed said their plans have been changed as a result of the election returns.

CAPITAL SPENDING IN MANUFACTURING

Of the $40.2-billion figure for all business listed above, the total for manufacturing is $14.4-billion—up 14 per cent. This compares with an increase of 34 per cent in 1956. The largest increases for 1957 are in the steel (32 per cent) and nonferrous metals industries (59 per cent), and in the chemicals (29 per cent) and petroleum refining (50 per cent). In these fields planned expenditures are so large that some may have to be carried over to 1958.

But there are some declines. The automobile industry spending will drop 20 per cent, reflecting the absence of a major model change in many lines. The big investment for that purpose was in 1956. Also down in spending are manufacturers of residential building materials, textiles, and various consumer goods like apparel and furniture. In the latter group, the many small firms, lower profits and credit difficulties were mentioned as the main factors.

In that respect, many companies are already scheduling higher spending for 1958. These are the steel, machinery, electrical machinery, chemical and rubber industries.

Of interest is the strong long-term expansion plans of the capital goods industries (machinery and electrical machinery). This, undoubtedly, is caused by the large amounts of advance business placed with these companies, particularly by the electric and gas utilities, and by companies engaged in the highway construction program.

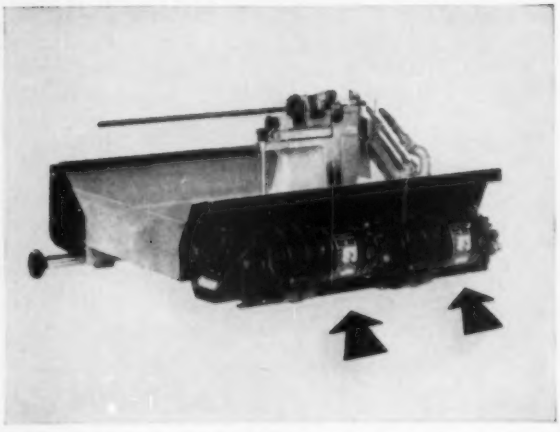
(Continued on page 131)

"CLOSE TOLERANCES...UNIFORMITY"

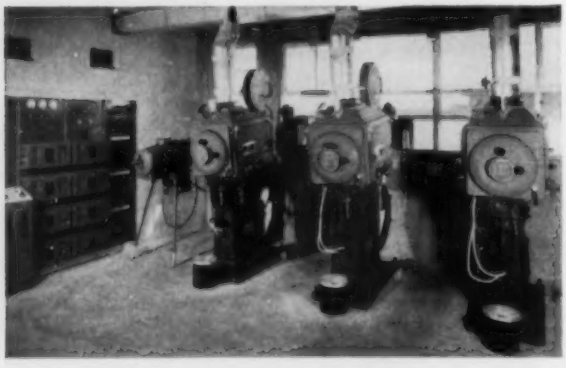
Reasons Strong Electric Corporation uses BODINE MOTORS

Bodine Type NSH-12R reducer motor

Two of these Bodine Type N reducer motors are used in each Strong Super "135" motion picture projection lamp. Strong found that only Bodine's wide selection of motors . . . over 3500 standard units, in all types and horsepower ratings (from 1/2000 to 1/6 hp) . . . could give them the speeds, power output and torque characteristics to meet their requirements. If *you* should require a *special* motor, this wide selection would hold costly modifications to a minimum.



Inside each Strong Super "135" motion picture projection lamp is this base and burner mechanism. The gear reduction ends of two Bodine Type NSH-12R motors drive negative and positive carbon feeds. Opposite ends of motors drive fans to cool lamp and stabilize arc. Dependable functioning of this automatic arc crater positioning system is important because a variation of only 1/32" can cause a loss of brightness and a change in light color.



Here are three Bodine-motor-powered Strong projection lamps ready for action . . . in the projection booth of the Miracle Mile Drive-In Theatre at Toledo, Ohio. These arc lamps, designed for use with new large screens, burn carbons at the rate of 18 to 30 or more inches per hour as compared to about 4 inches in old low intensity lamps. An automatic arc crater positioning system, driven by two Bodine motors, assures correct illumination.

Why are Bodine Motors used for Strong projection lamps? Mr. A. J. Hatch, president, The Strong Electric Corporation, Toledo, Ohio, gives these reasons:

"We needed a rugged and precision engineered motor for our Super 135 Motion Picture Projection Lamps, a motor providing dependable and trouble-free service. Only Bodine could supply motors with the speeds, power output and torque characteristics to meet our requirements. We like these motors because of their close tolerances and uniformity which makes them completely interchangeable."

Be sure *your* motor is as good as your product. For information contact Bodine Electric Company, 2260 West Ohio St., Chicago 12, Ill.

BODINE

fractional / horsepower

MOTORS

...the power behind the leading products

BODINE

Bodine manufactures fractional horsepower electric motors for:

adding machines, letter openers, sanders, vending machines, exhaust fans, duplicating machines, hand dryers, portable tools, sound recorders, air conditioners, check protectors, respirators, voltage regulators, X-ray timers, traffic signal timers, stirrers, calculating machines, envelope sealers, and for many other applications.

Perspectives

NON-MANUFACTURING INDUSTRIES

The electric and gas utilities are planning to invest $6-billion in new plants and equipment in 1957—up 25 per cent from 1956. This will be difficult to achieve, but together with the strong advance plans for 1958, it points up the magnitude of expansion in these industries in the next two years.

The oil industry will increase their expenditures by 50 per cent to expand and upgrade refinery capacity. The complex new processes required for higher quality gasolines cost much more per barrel of capacity than the older processes. Besides the new refineries, the oil industry is adding its own chemical plants, which add greatly to the total investment here. Construction difficulties caused expansion and modernization in 1956 to fall far short of the original goals. Although re-scheduled for 1957, some objectives will not be met before 1958.

At the time this survey was made, crude oil producers had plans for only a small increase in expenditures in 1957. This may reflect the difficult cost-price squeeze that affected crude oil producers in 1956. But renewed export demand, resulting from the Suez crisis could change this picture, leading to a larger increase in drilling and production. Unless more steel is made available, it may not be possible for drilling expenditures to increase very rapidly.

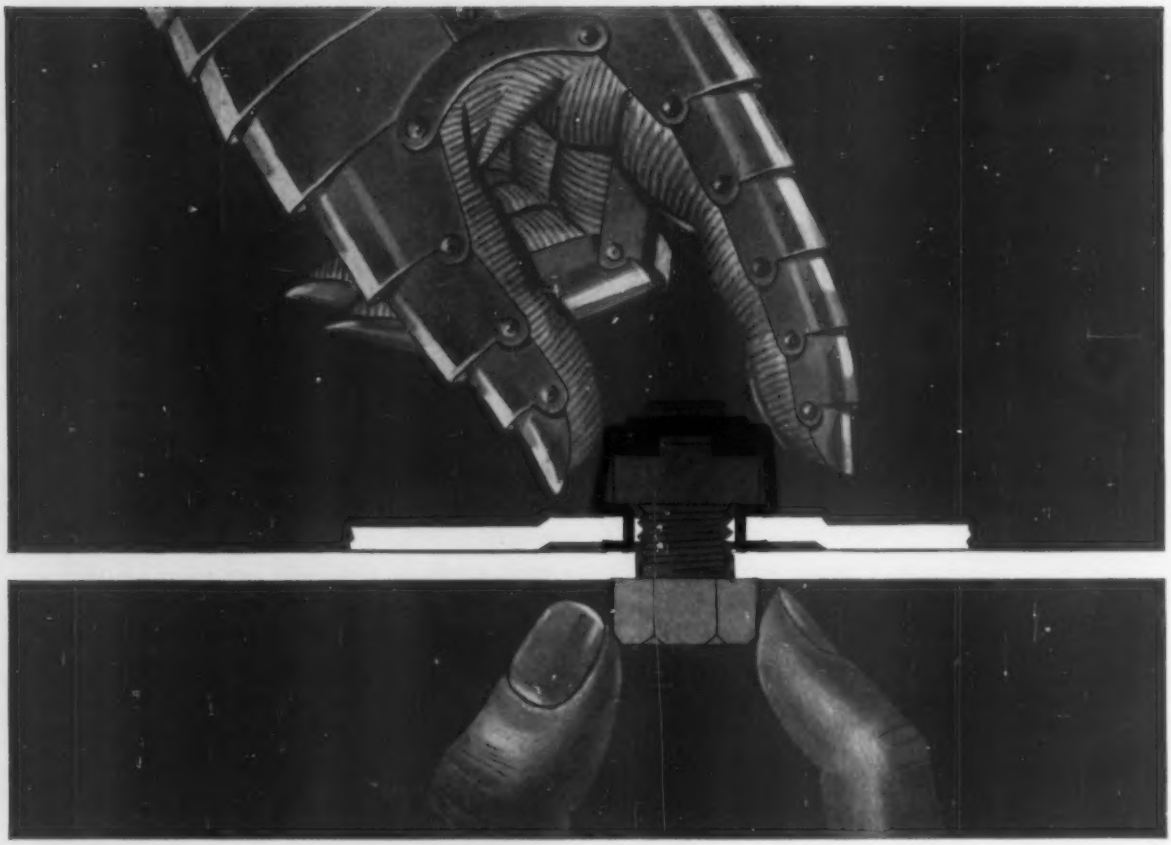
The mining industry plans to spend 9 per cent more in 1957 than in 1956, with large increases planned to develop the resources of iron and nonferrous ores. Most of these plans will continue in 1958. The program to develop usable ore from taconite and other low-grade deposits has passed the first phase. This program is not included in the mining total, but expenditures were about $140-million in 1956, and will be about $100-million in 1957 and later on.

Railroads are stretching out their construction and equipment programs. Outlay in 1956 was less than planned because of a delay in freight car deliveries, and because some railroads had difficulty raising money. For 1957, however, the railroads plan to increase total spending on roadway, structures, and rolling stock by 8 per cent. This is not much more than they foresee in the way of cost increases for this equipment, and much less than might be expected from the backlog of freight cars already ordered.

What could be classified as the "other transportation and communications" group plans for a 12 per cent greater outlay of funds. This includes expansion programs of broadcasting and other communications facilities; the continuing re-equipment of domestic airlines and increasing merchant ship program. Truck purchasing will be down.

THE WEAKEST LINK FOR 1957

Commercial business, despite higher prices for construction and equipment, is increasing expenditures by only 3 per cent. Department stores and other chain stores report a decline in spending, particularly for stores in large shopping centers. Smaller shopping centers are on the increase, however. Expansion is indicated for 1958, as mortgage credit becomes available. Business expects the prices paid for new plant and equipment to be about six per cent higher in 1957 than in 1956.



FINGERS OF STEEL
that hold where you can't reach

If you can't reach the back of a panel to hold a nut, let the spring steel fingers of a Tinnerman SPEED GRIP® Nut Retainer hold it for you. No welding or staking, no special skills or equipment required. It's the most efficient way to attach a square nut to a panel in blind location.

The SPEED GRIP combines a square nut retained in a spring steel cage. The SPEED GRIP snaps easily into the panel. Expensive rigid position methods are eliminated. Nut floats free in the cage to offset minor hole misalignments, but cannot turn as bolt is tightened.

SPEED GRIPS can be put on anywhere along your assembly line . . . no side trips to special stations, no line deviations of any kind. Rustproofed, they can be applied after painting, ending costly masking or retapping of paint-clogged threads.

Consult your Tinnerman representative soon and write for Bulletin No. 335. **Tinnerman Products, Inc., Box 6688, Department 12, Cleveland 1, Ohio.**

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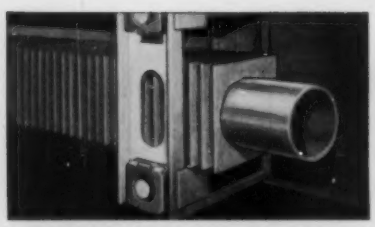
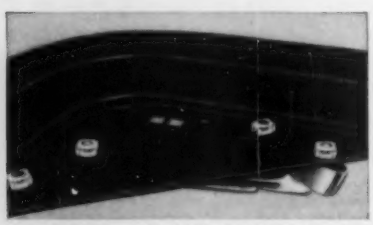


SPEED GRIPS eliminate several punched and tapped holes, cut assembly costs 78%, simplify installation of heater.



SPEED GRIPS applied *after* painting simplify blind-location assembly of auto seat handle, avoid paint-clogging of threads.

SPEED GRIPS cut costs 75% by replacing tapped holes and weld-type nuts as mounting fasteners on car radio.

G. F. NORDENHOLT

E. J. TANGERMAN

After 27 Years . . .

Since the inception of *Product Engineering* 27 years ago, the greatest single factor in its evolving policy and continuing growth has been its editor, George F. Nordenholt. His has been the responsibility for the editorial planning of the magazine, and to him belongs the major share of the credit for the high editorial standing of the publication.

The time has now come for Mr. Nordenholt to put down his burden. He will retire on July 1 of this year. We have sought long and carefully for his successor. Fortunately we had within McGraw-Hill a man who has known *Product Engineering* as long, although not as intimately, as has Mr. Nordenholt. In fact, he was the first news editor on the magazine.

As of January 1, E. J. Tangerman has been appointed executive editor of *Product Engineering*, to succeed to the editorship July 1. He brings to his new post a wealth of both engineering and editorial experience. He "grew up" in a railroad shop as the son of the late W. J. Tangerman, who held more than a hundred patents on railroad cars and accessories. He served his time as machinist apprentice, pipe fitter and boilermaker helper, then was graduated with distinction from Purdue University, from which he holds both the B.S.M.E. and the M.E. degrees. As editor in chief of the college daily, he chose technical journalism as a career. Four days after graduation, he began as assistant editor on *American Machinist*, progenitor of *Product Engineering*.

Since that time, Mr. Tangerman has been associated with some six McGraw-Hill publications, including basic editorial organization of the wartime aircraft technical monthly *Wings*, the *McGraw-Hill Digest*, and *Nucleonics*. For the past eleven years, he has been managing editor and executive editor of *American Machinist*, and in that capacity has been responsible for the publication's alert coverage of new technological advances in Metalworking. He has become recognized as an authority on personnel management, high-speed and high-feed machining, new machining methods, automation, and machine-tool design. He already enjoys a wide acquaintance among chief engineers of major machinery manufacturing companies. He is a registered professional engineer (N.Y.), a member of the A.S.M.E., American Ordnance Association, American Welding Society, Society of Plastics Industries, and other technical societies. He received several awards, including a medal from the Freedoms Foundation in 1955.

We are confident that, under his aggressive leadership, and with the support of the strong present editorial staff, operating under Robert W. Carson, managing editor, *Product Engineering* will go on to new heights of editorial service.

Publisher

FACTS

about

NEW DEPARTURE BALL BEARINGS

NINE REASONS WHY DISC PLOW BALL BEARINGS MEAN *SAVINGS*

SAVINGS FOR THE MANUFACTURER!

1. New Departure disc plow ball bearings require no adjustment for wear or preloading —eliminate threaded spindles, nuts, and washers.
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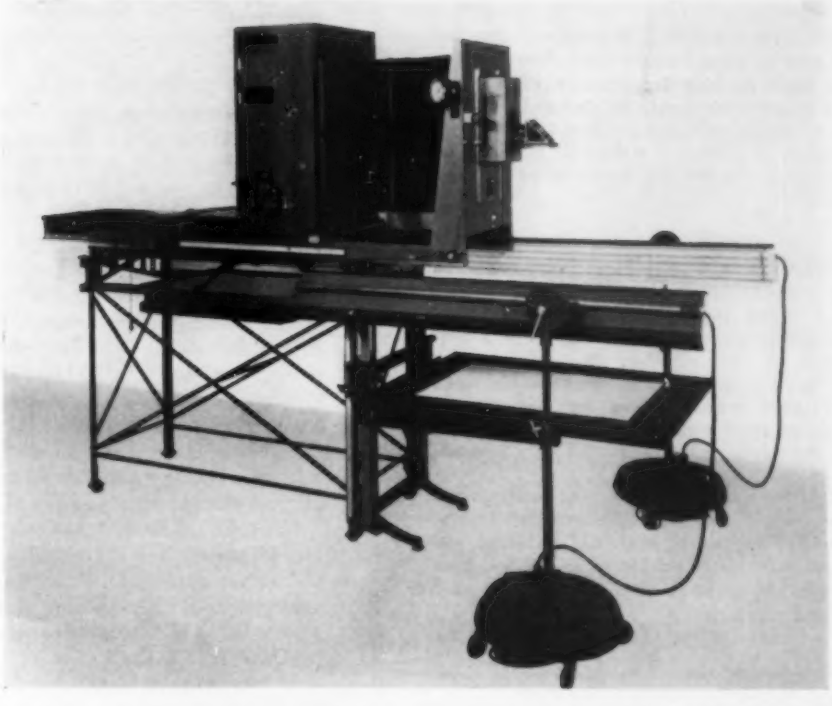
BALL BEARINGS MAKE GOOD PRODUCTS BETTER

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONN.

Choosing Equipment for

Drawing Reproduction



A Photostat Camera in which the original may be laid flat on the copy board (lower right). Sensitized paper within the camera is held vertical and receives its image from the prism and lens at the front of the camera.

A critical comparison of printing and photocopying machines as related to the needs of a medium sized engineering department. Techniques are included to revise or restore old drawings with a minimum of drafting time.

ARTHUR W. TABER
Peerless Photo Products, Inc.

TECHNIQUES FOR THE REPRODUCTION OF DRAWINGS, lists, and other forms of written communication are so varied that it is necessary here to limit discussion to the needs of a medium sized organization with average requirements. Much of what is said will apply equally well to larger or smaller companies, but it should be recognized that larger companies can afford to invest in more expensive, specialized equipment whereas smaller ones may be content to let a commercial photocopier or blueprinter handle special work.

In any company the basic need is to make a clear copy, correct in all detail and easily readable, of an original which may be translucent or opaque, at lowest cost and in a minimum amount of time. It should also be possible to make changes and modifications on drawings without laborious tracing by a draftsman.

Average Company Defined

A medium sized company will have an engineering department of approximately twenty men. They already have, or want to set up, a reproduction department under the supervision of engineering. The company may have

A BLUE PRINT MACHINE uses an iron sensitized paper requiring liquid development and drying in order to produce a "blue print":— namely, a white line on a blue background or, if the print is made from a negative, a blue line on a white background. Here negative means any original having a white line on a black or blue background, and it may be either direct reading or reverse reading.

A DIAZO MACHINE is one using an organic dye sensitized paper requiring either ammonia fumes or a liquid alkaline solution and drying, for development of the final print. These reproductions are often called dry process or blue line prints. Actually, they may be either blue line or black line depending upon the dye used. Other colors are also producible.

A PHOTOCOPY MACHINE, as considered here has a light source of lower intensity than either the blue print or diazo machine for exposure of a silver sensitized photographic paper. Original and sensitized copy paper are brought into intimate contact either by pressure or by creation of a vacuum. They may be run over a roller or laid flat depending on the type of machine.

PHOTOGRAPHY is distinguished from photocopy in that a lensed camera is used. This may be a copy camera, a process camera of either the dark room type or gallery type, a microfilm camera, or a flow type camera. A silver sensitized paper or film, more sensitive to light and, consequently, faster in speed than the paper ordinarily used for photocopy as defined above, is the reproducing medium.

OFFSET is a method ordinarily used to reproduce copies in quantities and in limited ranges of sizes, using standard duplicating machines. Sensitized materials are used only in producing the masters from which copies may be made. Copies are made on good quality bond paper.

other types of reproduction equipment but it is doubtful if these are supervised by the engineering department.

Common reproduction methods are listed and briefly described in the box above. Other methods are available to answer specific needs in specific industries. For example, Brown prints or Van Dykes use an iron silver sensitized paper that may be exposed on a blue print machine. Wash-off Tracing Cloth or CB's, as they are sometimes called, are sensitized with a bichromated silver emulsion. Under special conditions these materials might be most suitable but not for normal applications.

Quite arbitrarily then, the field has been narrowed to consideration of the simplest and most direct way of answering a typical company's needs.

Blueprints or Diazo Prints

If the original is a new pencil tracing either a blueprint or a diazo print is acceptable to the shop. Twenty years ago blueprints were made from tracings in whatever quantity required. Many companies made their original tracings in ink on cloth so that they could withstand repeated handling through the machine. Today, a pencil tracing would be used as the original. If a blueprint machine is the only machine available for reproduction, then the original tracing will be used each time a print is required. This handling often results in tears, dirt and a general deterioration of the original and, consequently, in the reproduction.

Diazo machine prints cost slightly more and will be either blue line or black line on a white background. This print is generally accepted in the plant today without question by the production department. Intermediate prints may be made from the original tracing on a thick translucent paper. These are sometimes referred to as sepia prints. The intermediate is used in place of the original tracing to produce the required number of prints. Original tracings are preserved in best possible condition since they must be run through the machine only once for each intermediate.

It is possible to use color in diazo prints to indicate degree of completion. For example, a blue line print may be considered final approved copy whereas a black line or a red line is not a shop print and may not be used for production.

Blueprint machines are limited to only one type and weight of paper. It is furnished in rolls requiring trimming of the finished print. Lower initial cost of paper serves to offset increased labor cost providing the volume used is large enough.

With a diazo machine, the choice of materials is wider. Printing stock is available in rolls or cut sheets, translucent or opaque. If cut sheets are used of the same size as the original, slightly more time is required in lining up the original with the sensitized paper.

Shelf life of both sensitized materials is quite satisfactory. Strength is comparable. Finished prints of both will have a tendency to fade when exposed to light over long periods of time. Either paper will deteriorate before use under poor storage conditions particularly in high heat and high humidity.

Additional Equipment Requirements

Production of a finished print from an original is only a part of the problem. Changes and modifications of original drawings may occur frequently and should be possible quickly and with a minimum of draftsman's time and expense. Supplementary equipment need not necessarily be occupied a full eight hours by the engineering department just to make changes and modifications. It is reasonable, then, to consider a type of equipment that may meet some of the reproduction requirements of office manager, accounting department, shipping department or sales and advertising department. The photocopy or photographic method of reproduction may answer these varied needs.

Materials used in these processes are coated with light-sensitive emulsions of the silver halide type and must be processed and handled in a dark room. Distinguishing features of these two methods are that photocopy is a method for making size for size reproductions while

photography permits size for size, enlarged or reduced reproductions.

Drawing sizes are usually limited to a maximum of 42 in. wide and 48 in. long or longer. In some special applications drawings may be 54 in. in width, and longer than 48 in. but these are usually confined to the aircraft industry. For practical purposes of this discussion the drawing 42 by 48 in. will be considered the largest needing reproduction.

For photographic reproduction it would be logical to use a process camera for such large drawings. Cameras limited to 24 x 24 in. originals require copying in sections. Process cameras will easily handle large sizes for reductions but the investment involved and space required would be high. In addition, only skilled operators can handle a process camera.

Photocopy seems to offer some very decided advantages. Rotary printers are available large enough to handle 42 in. wide prints or large size vacuum frames with a proper light source may be used as the exposure method. It is also possible to use a blueprint or diazo machine as the medium of exposure using the positive materials that are available. Of course a tray or tank set up for development of silver emulsion papers is needed and since there would be interference with the regular flow of work a completely new setup covering photocopy equipment is preferable.

A rotary printer for photocopy reproduction has certain limitations in flexibility. In some ways it duplicates the rotary machine that is used as a diazo or blueprint unit. A rotary unit will expose anything that may be run through the blueprint or diazo machine, however, reproductions may be required that will not go through a rotary machine satisfactorily but would be easily handled on a flat-bed printer or vacuum frame. Such work could involve reproductions of originals that are on cardboard or metal which can't be bent around a glass cylinder.

If such work is a part of the routine of the plant, then a vacuum frame is indicated. A rotary type unit for blueprints or diazo prints supplemented by a vacuum photocopier provide great flexibility since what may not be done on the one can be done on the other. Within its size limitaions, of course, a camera may be used to copy any original.

Revising Drawings

Photography and photocopy both offer the most flexible means to make changes and modifications on drawings with a minimum amount of redrafting. Suppose a blueprint is the only original available. A negative print of this blue print may be made. If lines or figures must be eliminated, opaquing will take lines from the copy made. This copy may be made on translucent paper or cloth and it becomes the new original from which corrected blueprints are made.

Closely related to the above problem is that of making prints from a drawing on opaque paper. In this case, it is necessary to make a reflex print by photocopy, or photography. To get best results, a negative is made on a paper with high contrast. If any corrections or changes are necessary on the final print, the negative may be opaqued.

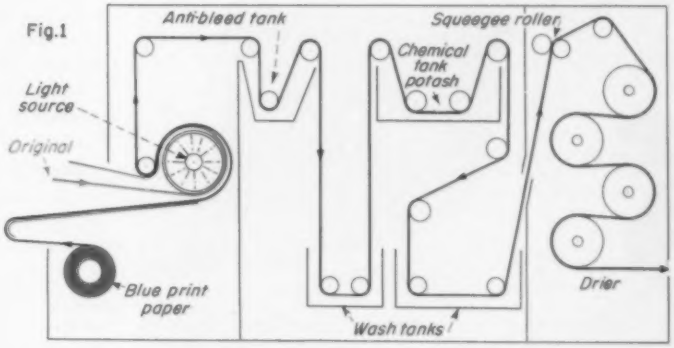
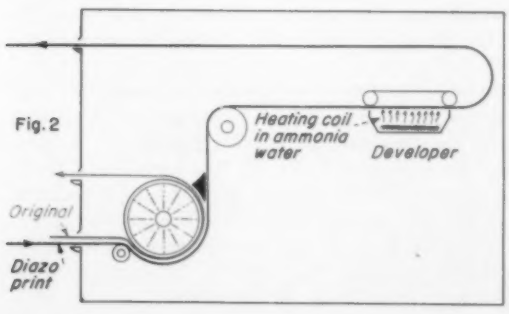


Fig. 1—Schematic diagram of exposure and development in the blueprint process. Only one type of blueprint paper is available. Originals must be translucent and flexible.

Fig. 2—Dry development diazo print machine. Many different kinds of paper are available for color prints on opaque or translucent paper. Wet development differs only in that print passes through liquid development and is subsequently dried.



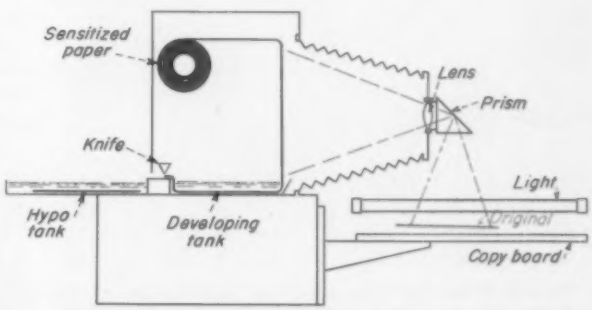


Fig. 3—Typical copy camera is limited to 42 in. width. Enlargements and reductions are possible.

A white background print is then made on the translucent paper or cloth. The draftsman may add the changes, if any, and the required number of corrected prints may then be made.

If the original is an old, dirty drawing with torn borders a reverse reading print should be made on good, sharp contrast translucent paper. Black out with ink, black paper or black tape all places which need revision. This applies, also, to the borders of the print. Now, a direct reading print may be made on contact paper or cloth that has all items except the desired revisions. A draftsman may incorporate revisions on the paper or cloth. The old print has not been damaged in any way and may be retained for record purposes. The intermediate is now equivalent to a new tracing.

Changes on photocopy materials may be made by the use of eradicators. Most engineers dislike eradicators, and proper use of materials makes them unnecessary. On cloth it is possible to make erasures with a soft non-abrasive eraser without damage to the fabric.

Photographic Methods

For drawings that do not exceed approximately 18 x 24 in. the copy camera may be used. For large size originals, the process camera is considered best. It is possible to accomplish photographically any of the results that may be obtained by the photocopy method already discussed. Materials used on the camera are of the projection speed type, making it necessary to work under dark room conditions.

The big advantage that the camera has is that enlargements or reductions are possible. In the past few years, there has been a tendency to use half size prints in the shop. Such prints may be produced on a flow type camera that will take originals up to 42 in. wide and any length. Savings in blueprint paper or diazo paper are considerable. The quality of the prints made on the camera is excellent and there is a choice of paper, film or cloth backing.

A Vacuum Printer provides one-to-one reproductions of flat originals. The copy paper is held in close contact with the original by a flexible blanket and the space between glass and blanket is then evacuated.

Often, an engineering department has the responsibility of making parts lists or instruction manuals requiring hundreds of copies usually in a 8½x11 in. size. A camera is necessary to get large prints down to the required size. Reductions may be made on either paper or film of high contrast in negative form so that plates for offset duplicating machine may be made. Once this satisfactory negative is made, it is comparatively easy to burn-in a plate on the new presensitized metal or paper plates. Hundreds of copies are easily produced on small offset duplicating machines.

Recommendations

Either a blueprint or diazo machine is essential since shop prints will be produced from original tracings or from intermediates on this unit. For the average size concern a diazo machine would be most adaptable. Many materials are available for a diazo machine whereas a blueprint machine is limited to blueprint paper of one quality. It is possible to expose Brown print or Van Dyke paper on blueprint machines by changing the developing solution. It is also possible today to purchase machines that may be used for either blueprint paper or the so-called positive papers with silver halide emulsions. However, only one type of paper may be processed at one time, since the developing chemicals differ for each. All blueprint machines are made for roll use, and are not adaptable to cut sheets.

Whichever is chosen, the basic machine must be supplemented by either photocopy or photography. Since drawings may be large—up to 42 x 48 in.—and the greatest demand is for size for size prints, photocopy is probably simpler and more economical. The only advantage that photography would have here would be the ability to reduce or enlarge the size of the originals. The number of reductions or enlargements required, if any, are probably a very very small percentage of the reproductions required. Consequently, a vacuum printer or rotary printer of the proper size to take the largest size print would be the most satisfactory type of supplementary equipment. The vacuum printer has the advantage of flexibility that a rotary printer lacks. It is possible to obtain a vacuum printer that has a light source that may be used to expose either the standard speed reflex papers or the positive papers.

With this selection of equipment intermediates may be made on paper, cloth or film for reproduction of shop prints on the diazo machine. Color coding may be used on the prints as reproduced on the diazo machine. There is a minimum of interference in turning out the required work as the two machines may be used simultaneously. Often when the load on one machine becomes excessive, it is possible to relieve this situation by doing some of the necessary reproduction on the other.

DRAWING REPRODUCTION TECHNIQUES

ORIGINAL	WANTED	METHOD
Pencil or ink drawing on cloth, paper, or vellum. Translucent paper.	To obtain size for size blueprint or diazo print for shop.	Copy on blueprint machine or diazo machine directly.
Intermediate, white line on black background, reverse reading.	Blue line on blueprint.	Copy on blueprint machine.
	Dark background on diazo paper.	Make a straight diazo print.
	Black on white background print.	Photocopy with photocopy paper.
Drawing to remain unchanged.	Shop prints incorporating changes.	Make negative print on reflex photocopy paper. Block out areas to be changed. Make intermediate on photocopy vellum or thin paper. Add new work to thin intermediate. Make blueprint or diazo print from intermediate. Note: Areas may be removed with eradicator but blocking out should be easier and more satisfactory.
Opaque or translucent drawing.	Black on white background print.	Photocopy with positive paper.
Blueprint.	Intermediate for shop prints.	Make reflex print on photocopy vellum or thin paper (black on white background). Make blueprint or diazo print from reflex print.
		Make reverse reading positive print (white line on black background). From this a diazo print will be white line on dark background. A blueprint will have blue line on white background.
Opaque drawing or printed both sides.	Size for size blueprint or diazo print.	Make reflex print, reverse reading on light weight photocopy paper, white on black background. ↓ Make shop print from this negative on blueprint paper (blue line on white background), or on diazo paper (white line on dark background). ↓ Make positive photocopy on vellum or lightweight paper. From this positive copy make blueprint or diazo print for shop.
		Make intermediate reflex print on positive paper. Make blueprint or diazo print from intermediate.
Plant layout using templates or aluminum plate with grid.	Shop prints for installation men.	Make reflex negative on high contrast photocopy paper to retain grid and template detail. Use this negative to make a positive photocopy on vellum or thin paper. From vellum or thin paper make blueprints or diazo prints.
Typed, printed, written or reproduced, one or both sides.	Intermediate for multiple copies on blueprint or diazo machines.	Make a reflex negative on high contrast photocopy paper. From this negative make a positive on photocopy vellum or thin paper. Use this method for up to 25 copies.
	To reduce to half size with good legibility.	Copy on any standard photocopy camera with half size setting. Result will be white on black background.
	Plate for use on offset machines.	Make negative on process camera either on film or high contrast paper. Negative may be same or reduced size. Burn in plate on standard frame.

In recommending the selection of the above equipment, reproduction of prints in reduced size for plate making by offset printing has not been considered. If this is a required service a camera would better replace the photocopier. The size and type would be dependent on the originals to be reduced, but if 42 x 48 in. is set as the upper limit, a process type of camera is indicated. A dark room camera is advisable for ease of operation and for results obtained. Note, however, that the cost is relatively high.

Over the past few years there has been extensive development in reproduction equipment and methods. Reference is made to microfilming, movie making, high speed photography, color photography, reduced size drawings, photomicrography, and many other special fields of photography too numerous and specialized to be considered here

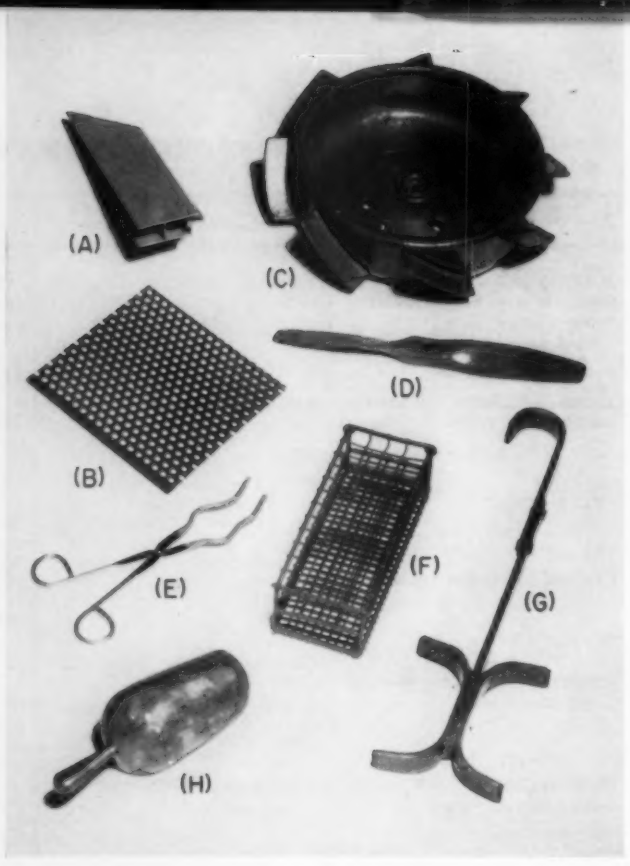


Fig. 1—Parts and materials protected with fluidized plastic coatings. Polyethylene coated items: (A) aluminum extrusion, (B) perforated sheet steel, (C) acid solution pump impeller, (D) chemical agitator, (E) laboratory forceps, (F) test tube rack and (G) electrolytic plating bath fixture. Polyethylene coatings may be colored blue, black, red, green and natural. (H) hand scoop coated with Fluorothene.

Fluidized Plastic Coatings *for Corrosion Resistance*

Powder dip process provides uniform corrosion-resistant plastic coatings on intricate parts; mechanism of fluidization, coatings available, cost factors, and applications.

DR. J. A. NEUMANN, American Agile Corporation
PROF. F. J. BOCKHOFF, Fenn College

THE PARTS SHOWN IN FIG. 1 have been protected with polyethylene by a process called fluidization coating. Result is an adherent, tough, corrosion- and electrically-resistant cladding. Parts to be coated are heated above the melting range of the plastic, then immersed for a few seconds in a bed of specially prepared plastic powder, maintained in a bubbling or "fluidized" condition by compressed air or inert gas. Upon removal, residual heat melts and levels the adhering powder particles to a smooth, non-porous resin coat.

Plastics presently used include polyethylene, nylon, some polyethers and certain fluorothenes. Conceivably, any thermoplastic resin may be used for fluidization coating if it exhibits reasonable stability toward degradation and oxidation above its melting range.

Advantages of this coating method are: (1) a short time is required to produce ready-to-use coatings; (2) elimination of solvent improves coating porosity compared to dispersion or solution-type coatings; (3) thick coatings can be applied in a single dip without sagging, running or crazing; on heavy metal parts, coatings up to 100 mils can be applied in a few dips without cure or cool-down between immersions; (4) coatings are uniform in thick-

Fig. 2—Drainage screen being fluidized with polyethylene. (A) Heated part ready for dipping. (B) Screen is immersed in fluidized powder bed for 1 minute. (C) After immersion, residual heat in part melts adhering powder particles into uniform coat.

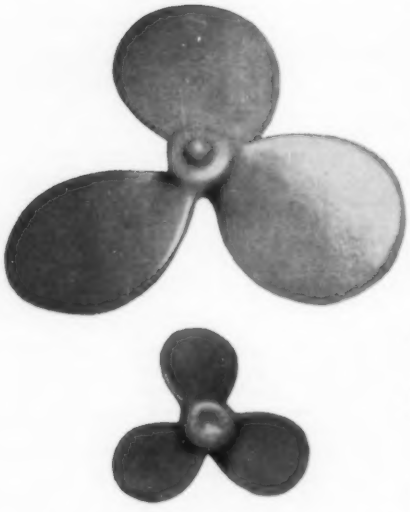


Fig. 3—Stirring propellers for acid and alkali solutions coated with polyethylene. Behavior of fluidized polyethylene in various corrosive environments is shown in Table I.

Table I—Corrosion Resistance of Fluidized Polyethylene Coating

Time and Temp.	Solution: Per Cent	Solution: Reagent	Weight	Per cent change in Tensile Strength	Ductility
3 months at 20 C	25	Sulfuric	+ 0.1	none	none
	25	Sulfuric	+ 0.1	none	none
	98	Sulfuric	+ 0.1	none	none
	25	Nitric	+ 0.1	none	none
	80	Nitric	+ 1.9	−10	−40
	95	Nitric	+ 6.9	−20	−75
	36	Hydrochloric	+ 0.1	none	none
	98	Phosphoric	+ 0.1	none	none
	25	Chromic	+ 0.1	none	none
	—	Formic	+ 0.1	none	none
	—	Citric	+ 0.1	none	none
	—	Lactic	+ 0.1	none	none
	30	Caustic Soda			
1 month at 40 C	50	Nitric	+ 1.9	−30	−55
1 month at 60 C	25	Sulfuric	+ 0.1	none	none
	80	Sulfuric	+ 0.1	none	none
	25	Nitric	+ 0.5	− 5	−10
	50	Nitric	+ 7.5	−50	−70
	36	Hydrochloric	+ 0.1	none	none
	98	Phosphoric	+ 0.1	none	none
1 week at 60 C	80	Nitric	+17.5	−90	−100

ness since the scrubbing, turbulent action of the fluidizer reaches the most recessed areas of the part; (5) there is no material loss compared to spraying when coating open-meshed or small objects; and (6) portable fluidizers can be used where on-the-spot protection must be applied.

Absence of solvent or plasticizers develops maximum corrosions resistance of polyethylenes or fluorothenes. Corrosion resistance of fluidized polyethylene coatings is indicated in Table I. Plasticizer blends are not required as in plastisol application, removing the problem of age embrittlement caused by plasticizers leaching or migration. Three plastic materials currently used for fluidized coatings are listed in Table II. Polyethylene coated propellers, Fig. 3, are a typical application.

Mechanism of Fluidization

Fluidized plastic powders have been used for coating applications since 1948, though the technique was not publicized until 1950 when a British patent was issued covering "a powder receptacle, in which an air jet and the opposing force of gravity circulated the powder . . . where the powder is kept in suspension." Fluidization is that unit operation in which a mass of solid particles, usually finely divided, is maintained by means of an upwardly moving gas stream in a turbulent dense state. Gas used is either compressed air or nitrogen depending on the oxidation tendency of the polymer.

Principal pressure gradient required for fluidization is that required by the gas to overcome friction in the bed

of closely packed powder. When the pressure drop across the bed approaches the unit area weight of the bed, the solids begin to move. This represents the initiation of fluidization which is similar to the bubbling of a gas through a liquid. Splashing occurs and streamers are occasionally ejected above the surface of the fluidized bed. When the container is tipped or rocked, the fluidized powder bed behaves like a liquid.

As gas velocity and pressure drop increases through the bed, the mean free path of the powder particles increases, gradually increasing bed porosity. Variation of pressure drop through the bed with superficial gas velocity is shown in the generalized curve of Fig. 4. Portion AB of the curve represents fixed-bed operation; no motion of particles is observed and the porosity of the bed remains constant. At point B the resin particles begin to move and the bed comes unstable. Point C represents the loosest arrangement of the particles which can remain in contact; this represents the beginning of fluidization. From C to D the bed expands in volume with a consequent increase in porosity. At D, fluidization is complete. Further increases in gas velocity beyond D give only slight pressure drop increases, due to increased fluid friction and entrance effects.

Optimum condition of operation is point D, which represents the minimum required pressure drop and superficial gas velocity for complete fluidization. A higher gas velocity creates an undesired increase in bed porosity, requires greater gas consumption and causes cooling of the part being coated. At D, porosity is high enough for easy dipping of articles to be coated.

Table II—Fluidized Coating Materials

	Max. Service Temp. F	Properties	Typical Applications
Conventional Polyethylene	170 F	Chemically inert Non-toxic, odorless, tasteless Tough, flexible Outstanding dielectric strength Excellent vapor barrier	*Corrosion resistant surfaces for:* Pickling racks and baskets Trays, small containers Impellers, stirrers Lab equipment Plating jigs and racks Fasteners Strainers, filler plates Gaskets, flanges Valves, pumps Rollers, floats Conveyors, hoppers Fan rotors and housings *Electrically insulating surfaces for:* Switch components Electrode holders Plating jigs and cells
Linear Polyethylene	240 F	Chemically inert Non-toxic Tough, semi-rigid Outstanding dielectric strength Excellent vapor barrier Good heat resistance	
Nylon	300 F	Excellent abrasion resistance Good bearing characteristics Tough, high strength High heat resistance Electrical insulator Chemically resistant	*Abrasion resistant bearing surfaces for:* Bushings, gears, bearings Electrical switch components Rollers and slides Valve seats Fasteners Motor parts Textile machinery parts

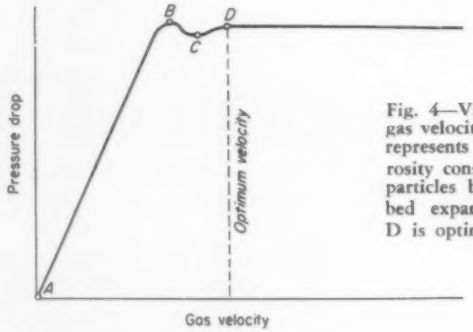


Fig. 4—Variation of pressure drop with gas velocity in fluidized bed. Region AB represents fixed-bed operation with porosity constant; at B, bed is unstable as particles begin to move; in region CD bed expands, porosity increases; point D is optimum operating condition.

Coating Process

Part to be coated is heated to a temperature above the melting point of the resin powder and submerged in the fluidized bed. Powder particles in contacting the hot surface form a partially melted coating whose thickness is dependent upon several factors: (1) ratio of weight to surface area, (2) preheat temperature, (3) fusion temperature of polymer, (4) thermal conductivity of polymer, (5) immersion time, (6) specific heats of polymer and object, (7) density of polymer. For example, the relationship between coating thickness, preheat temperature and immersion time for the coating of a steel panel with low modulus polyethylene is shown in Fig. 5. Curves vary considerably depending upon the polymer and the geometry of the part being coated. For an object having a greater weight-to-surface area ratio, the coating thickness would be proportionately greater.

After withdrawal from the bed, the outer surface of the coating is still grainy and unmelted. However, additional heat is soon conducted from the part to the coating surface causing complete fusion and leveling the coating. Occasionally, thin-walled objects do not furnish the required heat necessary for complete fusion after immersion. In these cases, a post-heating period in an oven is required.

Kinetic energy of the fluidized particles is sufficient to provide good adhesion to most properly cleaned metal surfaces. Coating adhesion, however, can be further improved by using proper pre-treatment. Treatment is generally of the surface conversion type and is specific for various types of metals.

Commercially available fluidization powders are modified to provide greater adhesion, better free-flow proper-

ties and better general operating characteristics. In most cases, non-modified powder plastics will not provide satisfactory operation.

Application

Several prepared powder blends are available for various temperature conditions and corrosion resistant requirements, three of which appear in Table II. Fluidized coatings of these materials are applied to such laboratory items as clamps, spatulas, test tube baskets, support racks, electrical components, trays, fasteners, small containers and electrically insulated tool handles. Commercially, fluidized coatings are used for strainers, filter plates, wire screen, impellers and other stirring equipment, pickling and dipping baskets, gaskets, flanges, valves, pump parts, bellows, rollers and various types of floats. Fig. 1 shows a group of such parts. A heavy impeller coated with polyethylene is shown in Fig. 6; note uniformity and smoothness of coating.

The process can be applied to specially shaped items by conducting fluidization entirely within the item to be coated. Fig. 7 shows a tank which is coated on the inside with polyethylene. The thickness of the coating is approximately 20 mils.

It is hard to generalize on fluidization coating costs. The following example, however, provides an order of magnitude yardstick: cost of polyethylene powder modified for fluidization is about $1.40 per pound, which covers 3½ sq ft to ⅛ in. thickness, for a material cost per sq ft of $0.40. To this must be added cost of cleaning, sandblasting and application of coating. Depending on complexity of shape and preparatory work necessary, total cost varies between $1.00 and $5.00 per sq ft.

In many applications fluidized plastic coatings provide quick, convenient and economical protection against corrosive environments. Adaptation of the fluidized coating process to continuous coating methods is under development; continuous wire and screen coatings appear entirely feasible.

EDITOR'S NOTE—Other techniques of protecting metals are discussed in the following recent articles:

"Changing for Resistance to Corrosion and Wear," November 1956 page 180, describes a process by which chromium is diffused in metallic surfaces.

"Vinyl Laminate," July 1956 page 167, describes bonding of PVC to sheet metal prior to forming operation. Coating is tough, has fair corrosion resistance and can be stamped to the desired form.

"Developments in Sprayed Metal Coatings," June 1956 page 194. New methods in spraying metal and ceramic coatings.

"Prefinished Aluminum," April 1956 page 135. How electrochemical paint and electroplated coatings stand forming operations.

Data on chemical resistance of resins and elastomers for coatings are included in "Organic Barriers for Corrosive Protection of Metals," in the Product Design Digest Issue published mid-October 1954, page C14.

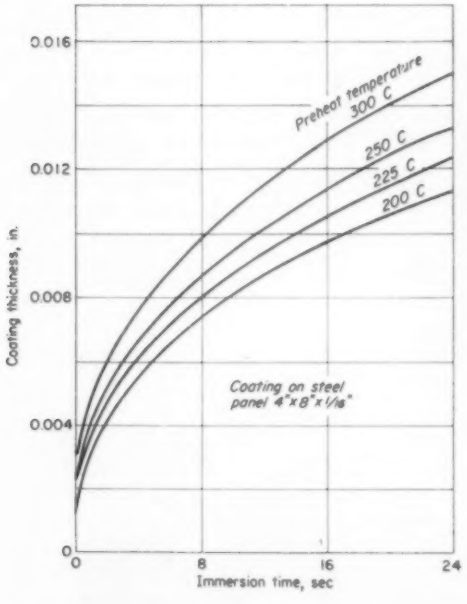


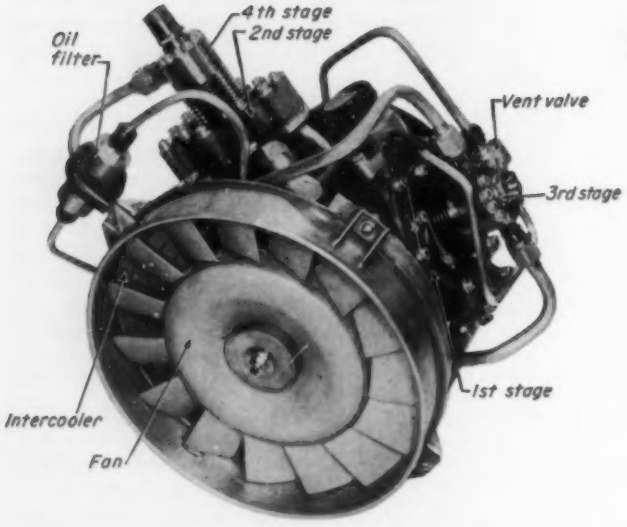
Fig. 5—Polyethylene coating thickness on steel plate as a function of preheat temperature and immersion time. Post heating is occasioally necessary on thin-walled objects for complete fusion.

Fig. 7—Fluidized bed placed inside tank to coat interior with polyetheylene 20 mils thick.

Fig. 6—Heavy pump impeller coated with polyethylene. Impeller diameter about 12 inches.

DESIGN FEATURES

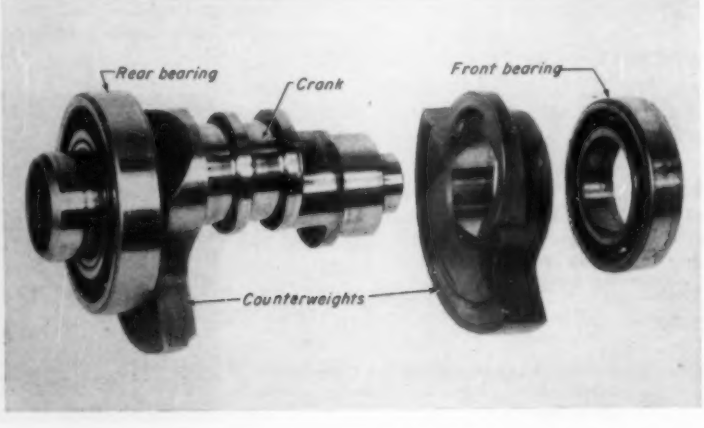
Stepped Pistons Simplify Compressor Construction

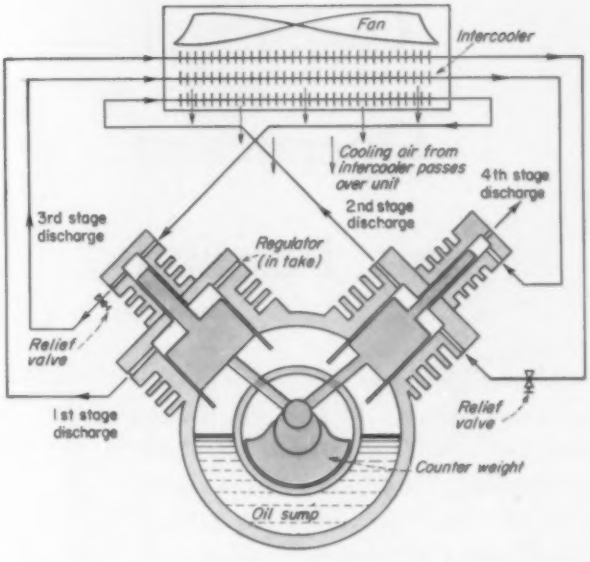


▲ **WRAPPING INTERCOOLER UNITS AROUND COMPRESSOR** and passing air in parallel streams across intercooler and crankcase makes best use of available volume. Connections between stages pass around compressor through intercoolers with hot and cold ends grouped together to form a cross-flow heat exchanger. Compressors of similar size, handling less volume, dissipate about ½ the heat removed from this machine which delivers 11.2 scfm at 3000 psig, with inlet air temperatures around 200 deg F. A slip clutch protects the fan from high accelerations when compressor is started and stopped. Concentric inlet and exhaust valves in each stage are light spring-loaded annular plates, operated with pressure differentials developed by piston motion. Inlet valve is in center on first two stages, as discharge valve lift is limited by dynamics of pressure rise and air flow. On last two stages, discharge valve is in center as air density is high and pistons have small diameters.

Mounting 3rd and 4th stage pistons on pistons of 1st and 2nd stages reduces the number of moving parts in a high-pressure, high-volume air compressor made for aircraft applications by Stratos, a division of Fairchild Engine & Airplane Corp. By increasing effective piston length, the stepped piston design improves alignment and piston stability, and is also the basis for compact and light construction. Compressor assembly includes intercoolers, cooling air fan, inlet pressure regulating valve, and relief and unloader valves. Other design features are a crankshaft with a removable counterweight, one-piece connecting rods, and a dry sump crankcase. All stages use piston rings to avoid lapped fits and mated parts.

CRANKSHAFT is threaded through one-piece connecting rods at assembly, and front counterweight is then locked in place. This design helps make unit compact as housing needs no ports for access to joints in crankshaft or connecting rods. Also, these parts can be lighter and still have sufficient strength for the high loads encountered. Crankshaft is supported on 2 ball bearings, and lubricating oil enters shaft from the pump through a close-fitting metering bushing forward of the front bearing; holes in the crankshaft distribute oil to the connecting rods and cylinders; counterweights pump oil out of the dry sump through ports in close fitting casing.

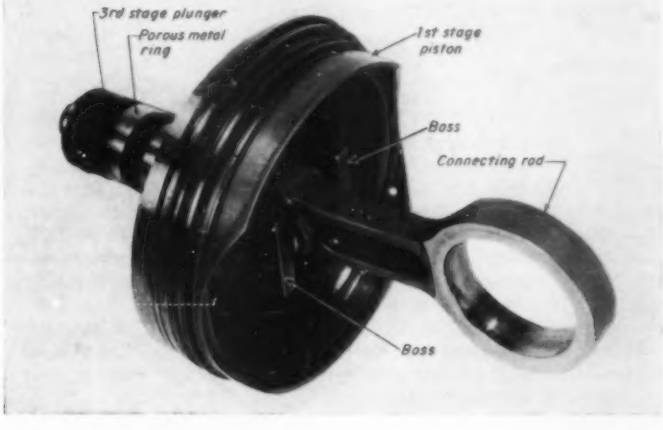




FOUR STAGES ARE USED to keep the compression ratio in each cylinder about 4 to 1 so discharge air temperatures remain below 500 deg F. This is a compromise between mechanical and thermodynamic design requirements, as the mechanical complexity of more stages would offset the therodynamic gains. When operating with 14 psia inlet air pressure, 4th stage compression ratio is about 3.3; it rises to 4.6 when inlet air pressure drops to 10 psia at high altitudes, and unit still develops 3000 psig discharge pressure. Stepped piston design requires only 2 connecting rods on a single-throw crankshaft and helps keep unit compact and simple; placing cylinders in form of a 90 deg "V" enables simple counterweights on crankshaft to compensate for primary unbalance forces. A check valve vent from the crankcase to the 1st stage inlet reduces oil consumption, but maintains adequate cylinder lubrication. Displacement effects of the 90 deg cylinder arrangement keep crankcase pressure below that of 1st stage inlet; air pumped through vent valve is equivalent to piston blow-by, which is quite small.

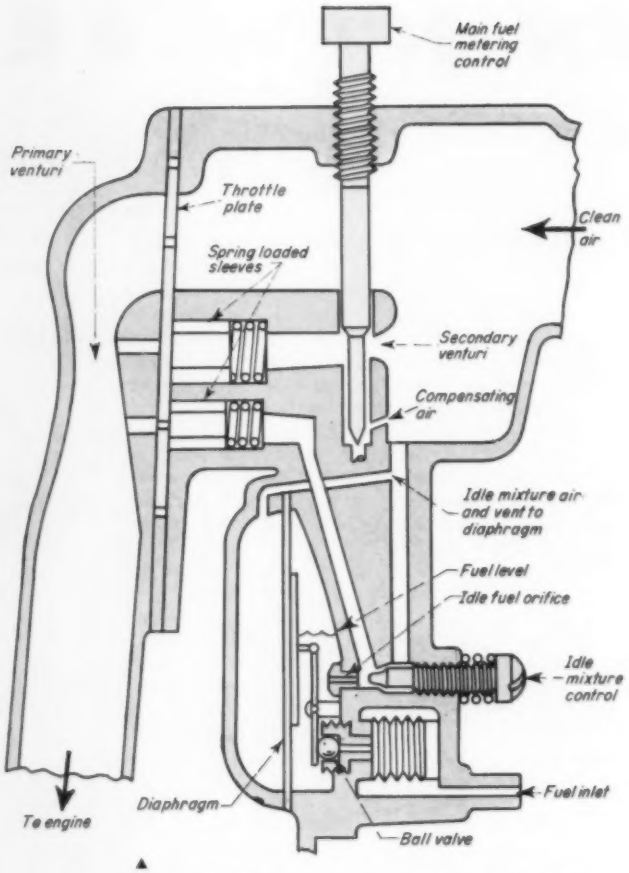
PRESSURE RELIEF VALVES are assembled integral with 1st stage inlet fittings and the discharge fittings of all but the 4th stage. Designed for the compact arrangement of this compressor, they are much smaller than commercially available units of similar capacity, and are spring loaded disk valves. Placing valves at interstage discharge fittings protects unit against intercooler blocking, as well as back flow if an inlet valve fails, and prevents any one stage from developing an excessive compression ratio if another stage fails. Unloader valve is also designed for this compressor and bypasses the air when accumulator or receiver is up to pressure. Valve has a diaphragm pilot which actuates an unloading plunger.

FIRST STAGE PISTON IS MADE SHORT by mounting wrist pin in bosses on bottom of head, which places it inside rings and flush with top surface. Pistons are tin plated steel to allow close fitting for good oil control with little chance of seizing. Stepped piston design increases stability with shorter skirt as a porous metal lubricating ring on the plunger acts as an outboard support. Connecting rods are solid with a bore at each end. At large end, needle bearings run directly in rod and are restrained axially by a spacer ring which also control oil flow. Bearings in small end have an outer shell with spun lips to retain the needles.

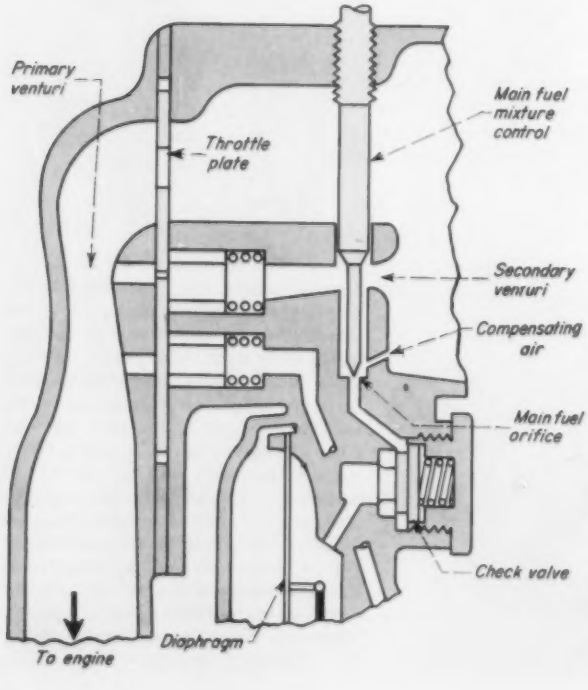


Carburetor Operates in Any Position

Chain saw carburetors must operate with the saw in any position. To make this possible, McCulloch Motors Corp., Los Angeles, Calif., uses a diaphragm in place of a float to regulate fuel level. Also, compactness and full-range mixture control are obtained by using a calibrated throttle plate instead of a butterfly valve to control engine speed, and by placing a relief valve in the main fuel system to prevent flooding when the engine is tilted. A felt wick picks up fuel in the tank and delivers it to the pump.



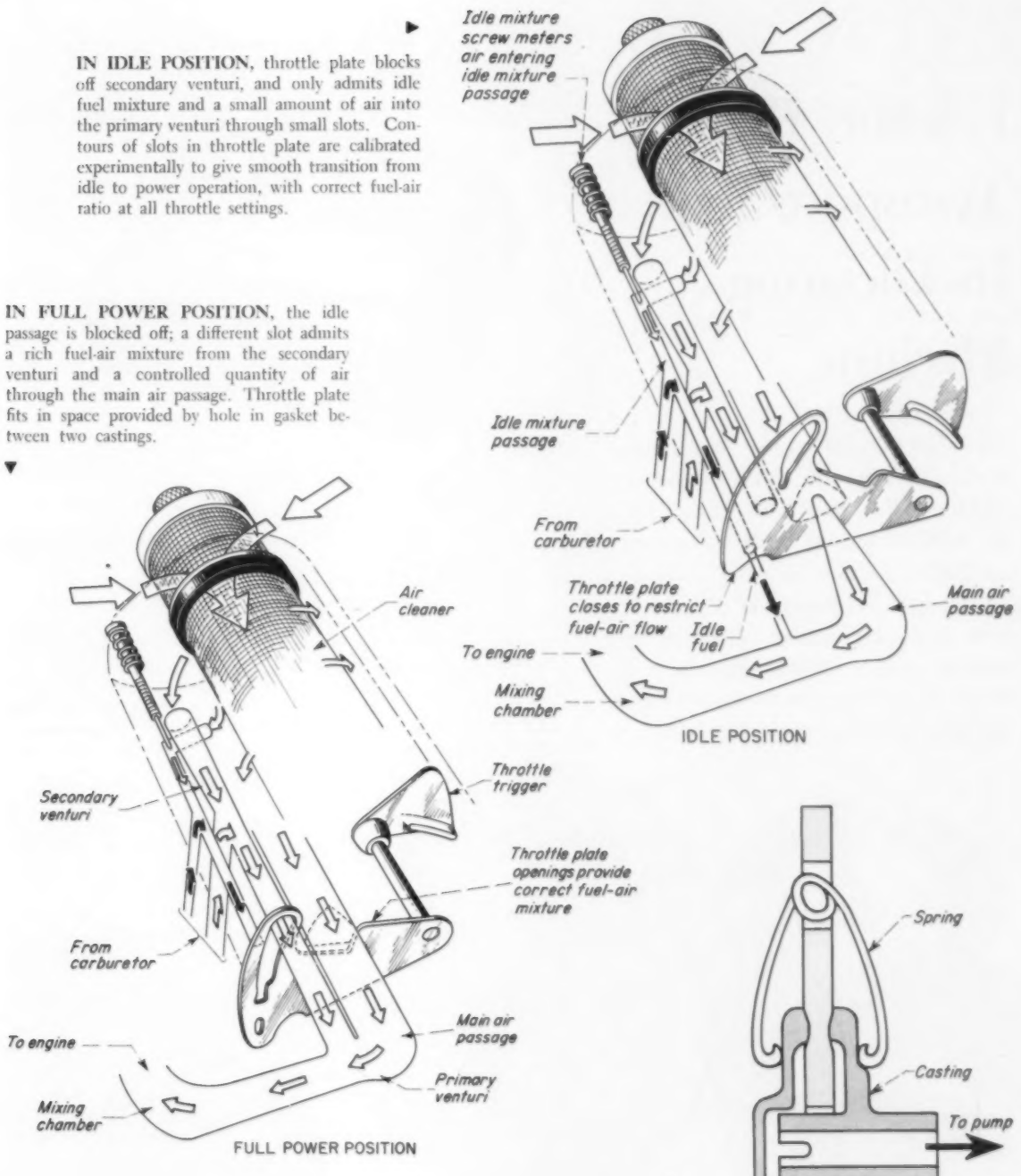
▲ **IDLE FUEL ORIFICE** is below gasoline level on wet side of diaphragm, and admits fuel to chamber where it mixes with air entering through idle mixture control. As throttle plate has closed off other air passages to engine, this mixture is drawn up through throttle plate into primary venturi. Fuel level on wet side of diaphragm regulates ball valve position to control fuel flow into the carburetor. Dry side of diaphragm is vented to air inlet so pressure differentials across both fuel and air orifices will be the same. This allows relative orifice areas to set fuel-air ratio. Sleeves in mixture passages are spring loaded against the throttle plate to form effective seals.

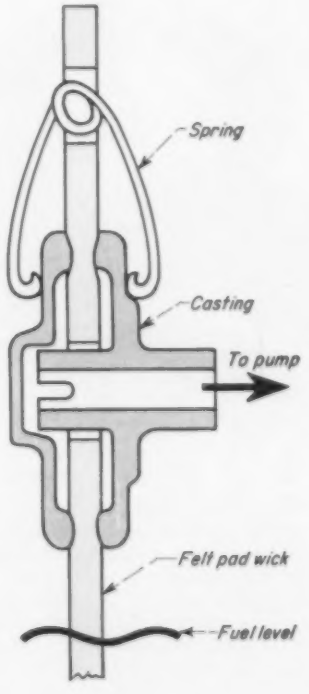


◀ **MAIN FUEL SYSTEM** uses a secondary venturi to lift fuel from center of diaphragm to holes which admit compensating air at main fuel orifice. This puts wet side of diaphragm under slight suction which tends to draw air into this chamber, through the idle orifice, when operating on main fuel system. Placing idle orifice below fuel level prevents air from entering diaphragm chamber and altering fuel-air ratio of main system. A check valve prevents gasoline from running out through the main fuel orifice when the engine operates on its side, or inverted; this would flood the engine under idling conditions. Valve also prevents air entering the diaphragm chamber and affecting the idle system.

IN IDLE POSITION, throttle plate blocks off secondary venturi, and only admits idle fuel mixture and a small amount of air into the primary venturi through small slots. Contours of slots in throttle plate are calibrated experimentally to give smooth transition from idle to power operation, with correct fuel-air ratio at all throttle settings.

IN FULL POWER POSITION, the idle passage is blocked off; a different slot admits a rich fuel-air mixture from the secondary venturi and a controlled quantity of air through the main air passage. Throttle plate fits in space provided by hole in gasket between two castings.



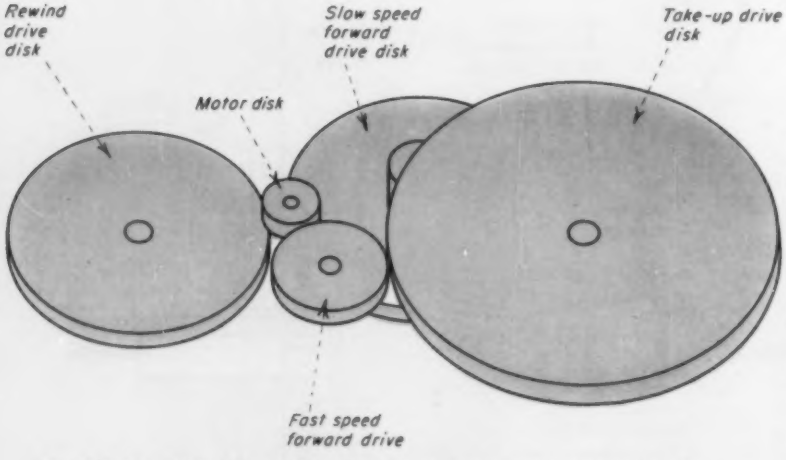


FUEL PICKUP SYSTEM consists of felt pad which absorbs fuel from low level when tank is nearly empty, or from splash, which is a major factor with the engine vibrating at high speed. Fuel is drawn off wick through castings which are pressed against it by springs, and drawn into the pump. Pick off casting design needed adequate area for wick to handle required liquid volume, and intimate contact between wick and castings to make a capillary seal which prevents leakage of air. When liquid level is above point where fuel is drawn off wick, suction only overcomes flow resistance; additional suction is required for lifting when liquid level is below pick off point. Castings had to be clamped with springs, rather than rivets; when riveted, tolerances on felt and castings squeezed felt until area was too small to pass liquid.

Friction Drive Transports Tape In Dictating Machine

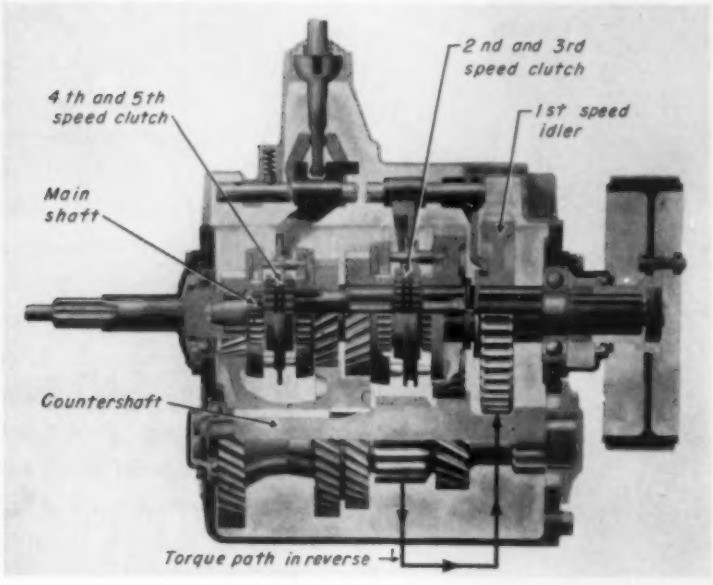
Standard magnetic tape is the recording medium in a low-cost dictating machine made in West Germany by the Grundig Co. and marketed here by DeJur-Amsco Corp. An inverted synchronous motor drives the tape transport mechanism and, because it is small, is the key element in making the machine compact. Motor's heavy rotor is the flywheel governor for friction disks and slip clutches which control tape motion.

TAPE IS LOOPED OVER CENTER OF SPOOLS and stops as either end is reached, when high torque makes clutches slip. Although similar to a tape recorder, unit is designed specifically for speech reproduction with good frequency response from 100 to 4500 cps. Tape records on one track, is non-reversible, and holds 30 minutes of dictation at normal recording speed. All controls are at front of machine and are marked with functional symbols or numerals to avoid language barriers. Progress scale mounted over feed spool is operated mechanically by a pickup arm which rides tape on the take-up spool. This scale makes it possible to locate any point on the tape when recording or transcribing. Push buttons on the machine or on remote-control accessories control all operating functions. Unit is 11½ x 9½ x 4½, weighs about 11 lb and uses 35 watts of ac power.



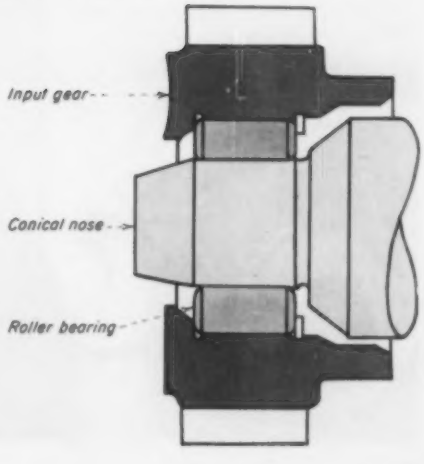
FRICTION DISKS, which drive take-up spool and rewind feed spool, ride directly on the motor shaft. Recording drive has two stages of speed reduction while one stage is used for rewinding; fast forward drive is obtained with a one-stage reduction driven from disk on the motor shaft. In stop position, all drive disks are disengaged from motor. Take-up and rewind push buttons energize solenoids which shift friction disks into contact with motor. Take-up drive disk and motor have fixed axes; all other disks are positioned by solenoids. Backspacing on recording or playback is obtained with a relay, an interlock, and a condenser which times the sequence of motions initiated by depressing buttons on microphone.

Shot Peened Gears Increase Torque Rating of Transmission



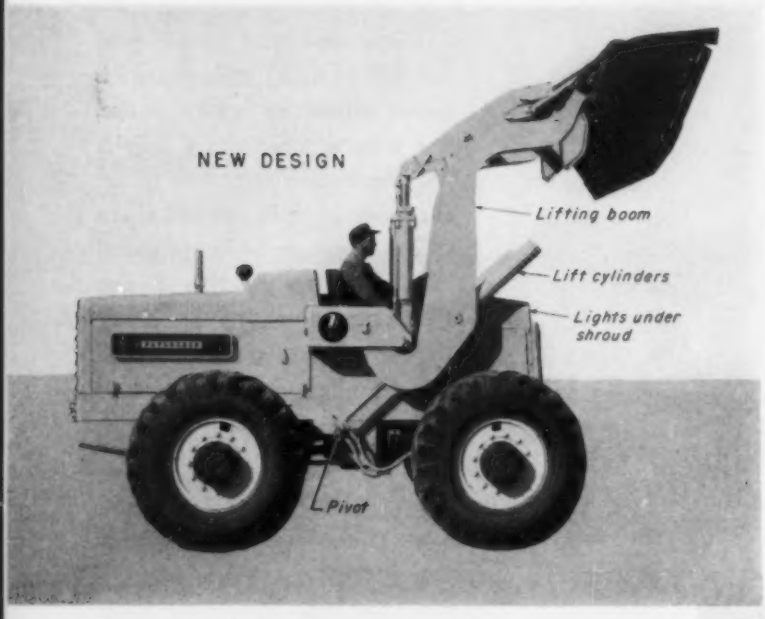
Torque capacity of this five-speed heavy-duty truck transmission is greater without an increase in size, and with a reduction in weight. Also, by synchronizing four of the five forward speeds, the unit is less subject to damage by inexperienced operators. Made by New Process Gear Corporation, Syracuse, N. Y., the transmission has die cast aluminum synchronizing rings and uses a sliding idler gear to shift into reverse.

▲ **INCREASED TORQUE CAPACITY** with same tooth width is obtained by shot peening all gears. This also reduces gear noise by making a more easily lubricated surface finish. Sliding the idler gear (not shown) to shift into reverse shortens shafts as there is one less gear on the countershaft. These factors helped to keep overall length of previous design while adding synchronizing clutches for 2nd and 3rd forward speeds. Four rails and forks are used for shifting. Synchronizing rings are aluminum die castings with hardened blocking pins cast as inserts; on previous design, the pins were riveted to the ring. Weight is reduced from 210 to 182 lb by using aluminum in place of cast iron for the cover and the rear countershaft bearing retainer.



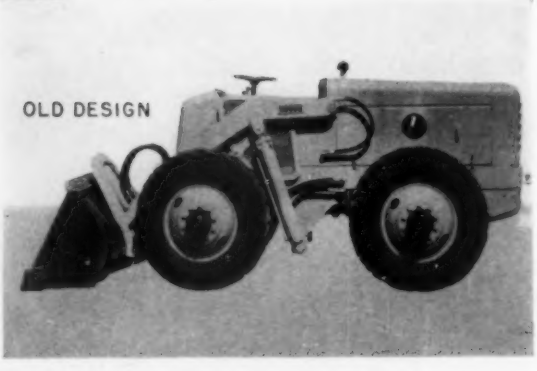
▶ **PILOT ROLLER BEARINGS** on main shaft are lubricated by slinging oil against a conical shaft nose which then pumps an even flow into the bearing. Flats ground on the main shaft carry oil under hubs of constant mesh gears which run directly on the shaft; old design used bronze bushings pressed into hubs. Shaft surface is chemically treated to produce an oil retaining porous surface for initial lubrication. In operation, shaft surface is splash lubricated by oil slung from overhanging edges of gears on countershaft; oil reaches shaft through slots in gear hubs.

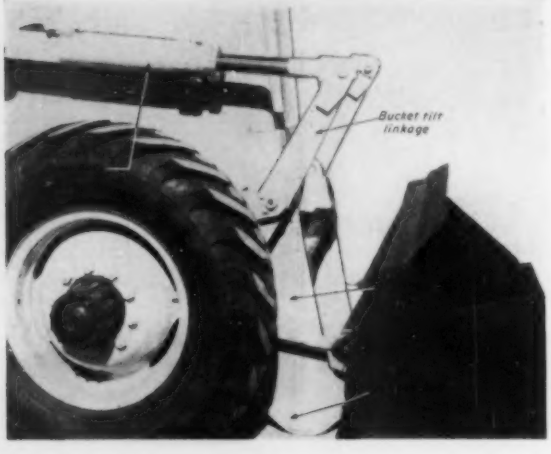
Tractor Shovel Lifts Higher, Is Safer for Operator



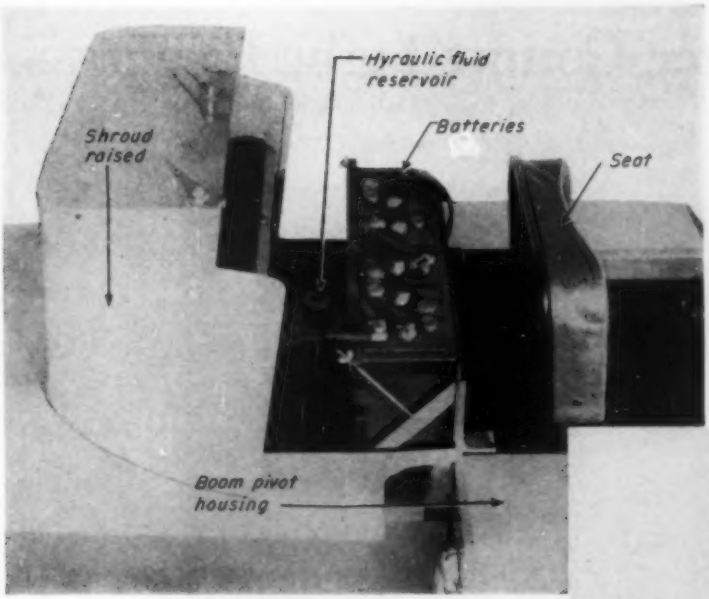
When the Frank G. Hough Co. of Libertyville, Ill., redesigned their line of tractor shovels, lifting booms were lengthened to raise bucket higher, and reshaped for greater safety. Improvements were not limited to functional mechanisms, but included product styling. Engineering and styling were directed within the company by Ralph Beyerstedt, Executive Vice President in charge of engineering. Then, styling was finalized by industrial design firm of Jon Hauser. Machine is first of this kind selected for honors by Industrial Design Institute.

▲ **LIFTING BOOMS HAVE GOOSE-NECK CONTOUR** to keep them in front of operator when bucket is raised. Operator's compartment has been moved back for equalized visibility in both directions, and to keep him away from material which might fall from bucket. Lowered front shroud also increases visibility, and shields headlights from falling objects. Note inverted hydraulic cylinders mounted on trunnions in the "U" shaped boom with hydraulic connections at fixed pivot for short hose lengths. Cylinders are hidden by booms when bucket is lowered.





◀ **PRY-OUT PADS** support vertical sections of lifting booms and transmit pivot forces directly to ground when bucket tilt cylinder is used to loosen rocks or virgin soil. Linkage is designed to rotate bucket to carrying position while at ground level to reduce spilling, and to keep it level when lifting. A gas filled accumulator in hydraulic circuit of the lifting booms absorbs road shocks to help keep bucket level.

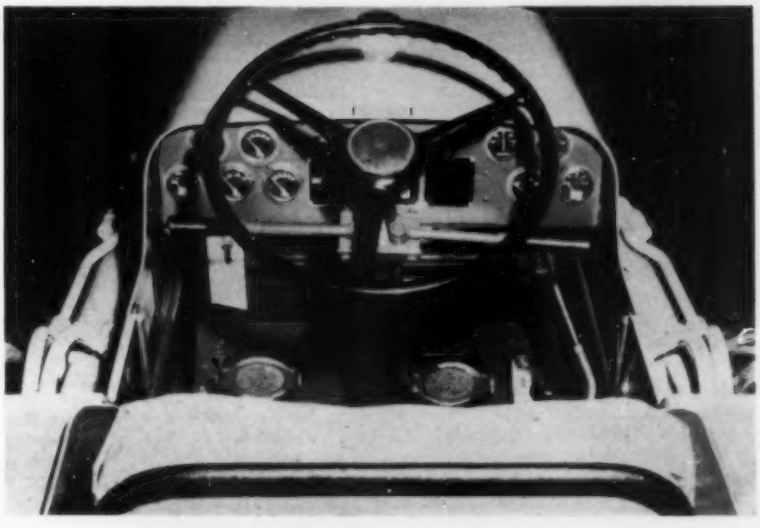


◀

RAISING SEAT increased visibility, but required a shroud to fair it into main body lines. Space under shroud is utilized for batteries and reservoir for hydraulic fluid, which must be accessible for frequent inspection. Housings for boom pivots not only hide the mechanism to improve appearance, but serve as arm rests and steps, and house back-up lights.

CONTROLS AND INSTRUMENTS are arranged to facilitate motion coordination and to utilize operators instincts. Brakes can be operated with either foot. The left brake is used when preparing to lift and dump, and puts the hydraulic clutches of the automatic transmission in neutral so full speed hydraulic effort is available for lifting. The right brake is for road use when engine braking is desired, and does not disengage transmission. Operators seat has a curved back which supports the shoulders, and a seat which is adjustable fore and aft.

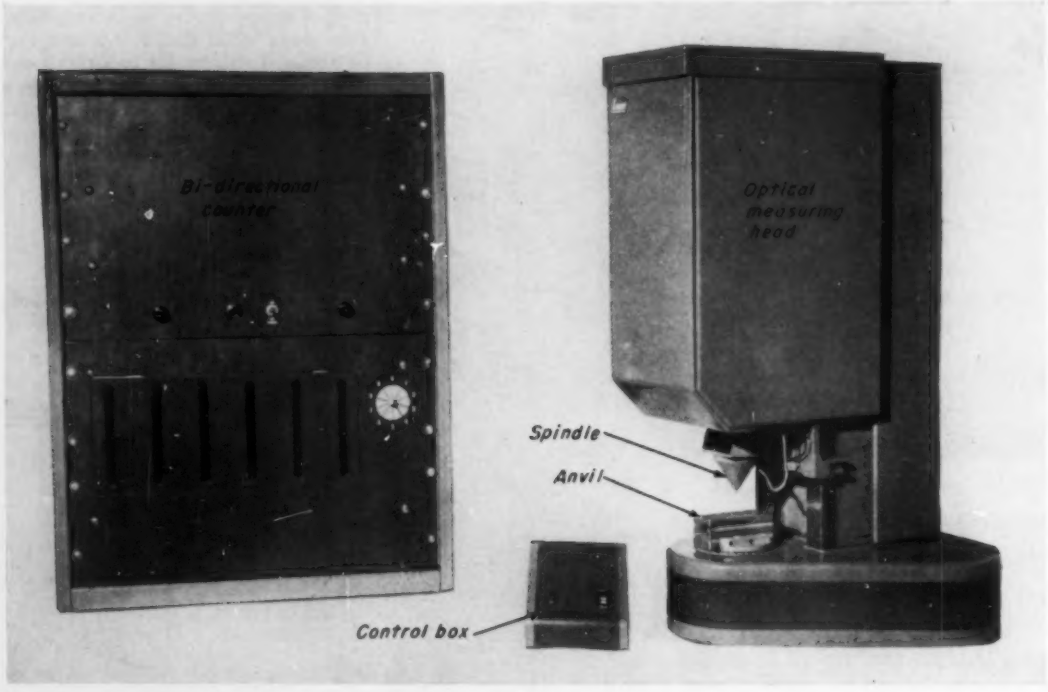
▼



▲

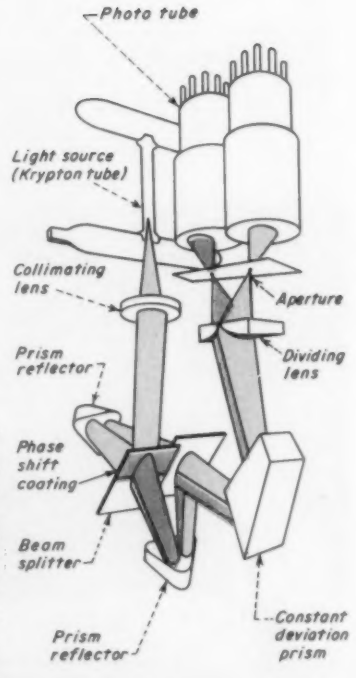
PRODUCT IDENTITY is established by contours evolved from previous design, color scheme, and identifying structures. Heavy grill at rear, and raised grill on side panels blend into lines of machine and add interest to set off simple lines. "Payloader" in raised letters above rear grill and on side grills cannot be effaced if machine is repainted by contractor. Buff and brown color scheme is distinctive, and is practical for service in normal operating areas.

Micrometer Counts Light Fringes



▲

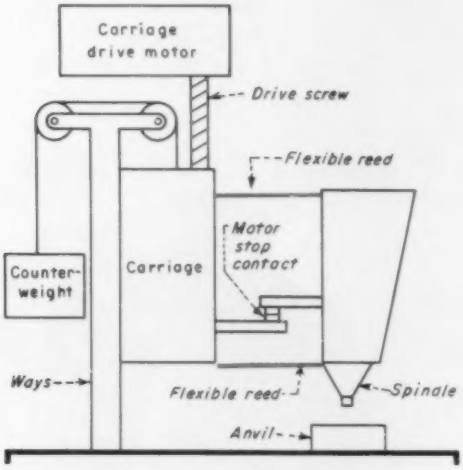
THREE SEPARATE UNITS form the micrometer; optical measuring head, a control box, and a bi-directional digital counter which displays the dimension of the part being measured. Fringecount indicated on digital display is multiplied by half-wave length of light source for conversion to standard units. One leg of interferometer is formed by the light path to a reflecting prism on the movable measuring spindle; spindle is mounted on a carriage positioned with simple electrical controls. Counterbalancing the carriage reduces torque requirements, so carriage is driven by a shaded pole motor. Motor and other heat producing components are in top section of measuring unit to reduce effect on stability of optical system. Micrometer must be in thermal equilibrium with surroundings before measurements are made. Spindle is operated with a reversing switch on a small control box which also has a button for zeroing the counter. Before making a series of measurements, spindle is positioned against anvil and counter is set at zero. Successive measurements of various size parts within range of micrometer can then be made as reversible counter senses direction of spindle motion and always indicates position relative to established zero.



▶

LIGHT FROM THE SOURCE is passed through a beam splitting element to form separate beams for the reference and measuring legs of the interferometer. Both legs have corner prisms to reflect the light to a second beam splitting element where interference fringes are formed. The combined beam is then directed to photo tubes where fringes are counted when the measuring spindle moves. Coated half of first beam splitter produces a phase shift in part of the beam directed to measuring head. Fringes formed by this beam section are out of phase and are sensed by a different photo tube from fringes formed by the non-retarded beam section. Phase-shift displacement of the fringes is sensed by a special arrangement of electronic counting tubes to synchronize count-direction with motion of measuring spindle.

..A dual interferometer is combined with a bi-directional digital counter to make an instrument for direct measurements accurate to one-tenth of a light fringe under controlled conditions. A phase shift in the fringe pattern indicates direction of spindle motion so counter always reads spindle position. Called the Fringecount Micrometer, it is made by Link Aviation, Inc., Binghamton, N. Y.

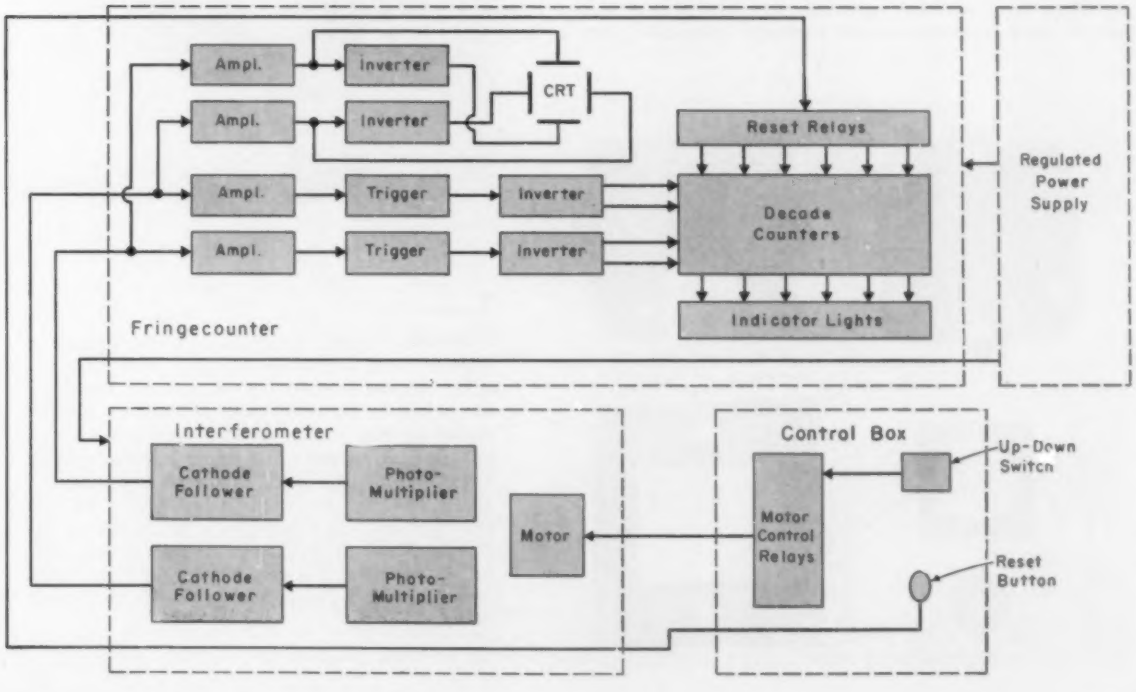


METAL REEDS SUPPORT MEASURING SPINDLE which is counterbalanced to preset the measuring force. When carriage brings spindle in contact with workpiece, spindle is lifted off lower contact to stop drive motor. User can preset measuring forces of 1, 4, 8 or 16 oz to meet his requirements by changing counterweights, which also are supported on a reed pivot to avoid friction errors. Designers first considered using a non-contact probe method to avoid errors from deflection of probe and workpiece. Problems encountered in designing accurate positioning, follow-up, and sensing systems were complicated, and mechanical contact system was finally selected for simplicity and low cost. Light measuring forces avoid the deflection problem, and friction in slow speed drive stops carriage within required limits for repeat readings. Carriage is spring loaded against ways which are ground to precision required for a good machine tool. Alignment of ways and spindle must be good, but are not critical; reflecting prism overcomes the alignment problems of plane mirror elements by keeping reflected and incident light paths parallel.

◀

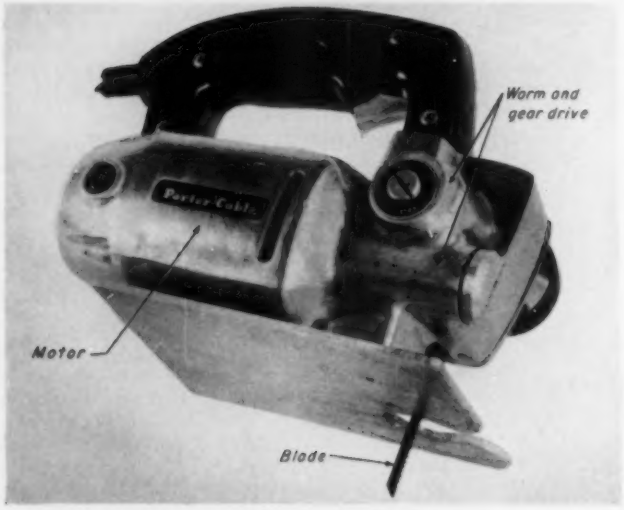
PHOTOTUBE SIGNALS are dc amplified and applied to plates of a 2 in. dia cathode ray tube where a dot is displayed which moves in a circle as the measuring spindle moves up and down. Dividing the circle into 10 segments forms a vernier readout as 1 revolution of the dot represents a count of 1 fringe. Count direction is synchronized with spindle motion by applying phase-shifted signals to electrodes of glow transfer counting tubes, which are so interconnected that the time sequence of potentials determines direction of counting. This circuit also prevents backlash in the digital indication. Dc coupling gives counter ability to count in either direction at speeds from zero to the maximum rate.

▼

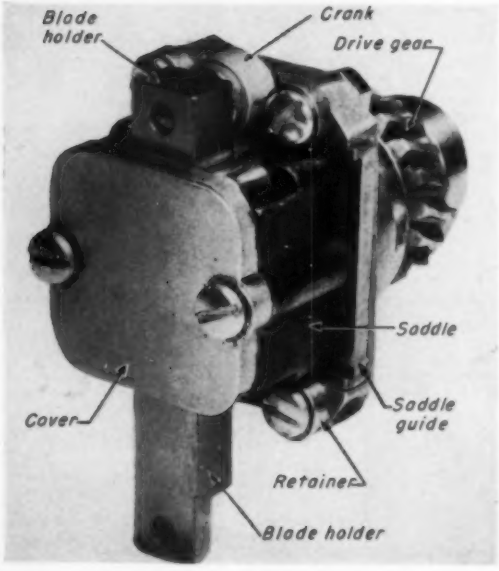


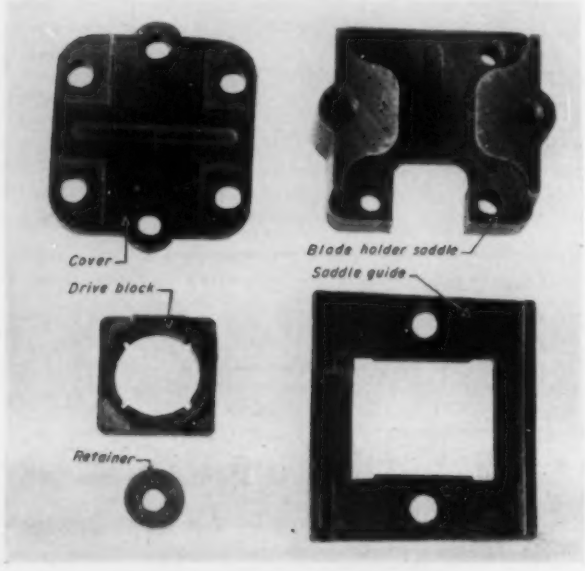
Orbital Motion Mechanism Drives Saw Blade

The blade moves into the work for the cutting stroke and is backed away for the return stroke in a portable electric jigsaw made by Porter-Cable Machine Co., Syracuse, N. Y. This action reduces effect of heat on saw blades and also makes the blade cut faster. Extensive use of powder metal parts in blade actuating mechanism lowers its cost and makes the design feasible.



BLADE ACTUATING MECHANISM is driven through worm and gear by motor in rear of cast aluminum housing, and orbital motion is obtained by the combined action of a cam and an eccentric pin. Cam causes a drive block to oscillate in the horizontal plane, while the pin drives a crank which imparts vertical harmonic motion to the blade holder. As crosshead carries slide in which blade holder moves, resultant blade motion is an ellipse with a very small minor axis. Counterweights are built into the worm gear to balance inertia forces of reciprocating parts.

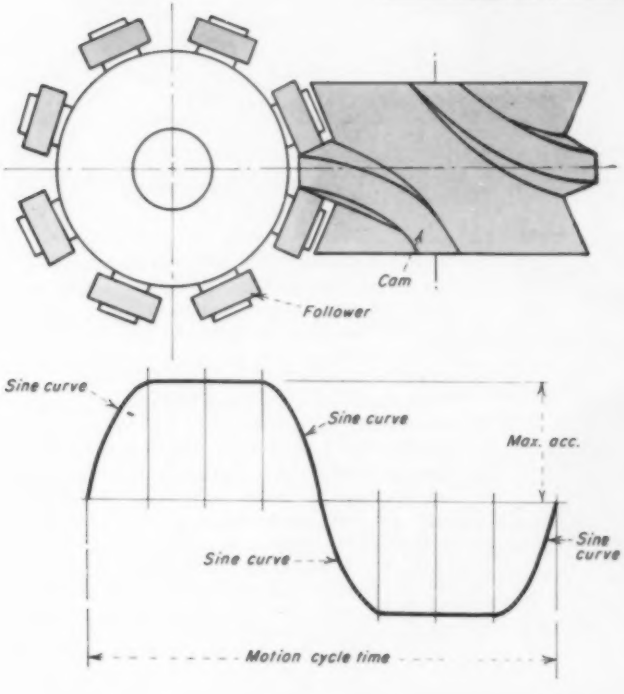




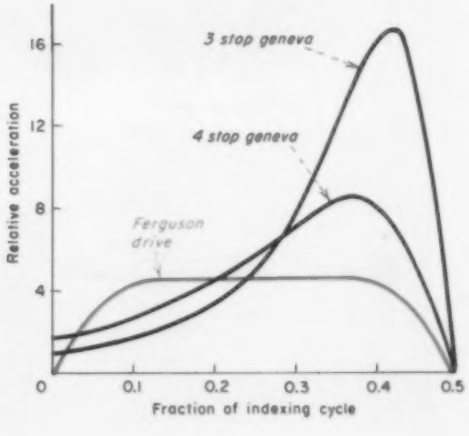
POWDER METAL PARTS are used in 5 places in blade actuating mechanism to obtain close tolerances at low cost and good bearing characteristics. Powdered iron is used for the blade holder saddle which is steam treated for high surface density. This increases wear and corrosion resistance, but retains sufficient porosity to hold oil for lubrication. Saddle guide is maximum density powdered iron which is heat treated for high wear resistance. Oil impregnated bronze is used for the drive block and the mechanism retainers as these parts are not lubricated; it is used also for the blade holder cover which is a bearing surface for the steel blade holder.

High Speed Cam Drives Indexing Table

A concave barrel cam with predetermined acceleration characteristics is used by Ferguson Machine Corp., St. Louis, Mo., to position their indexing tables at rates up to 1000 indexes per minute. Cam and follower design prevent backlash and lock table in dwell position.



MODIFIED TRAPEZOIDAL ACCELERATION characteristic has zero initial force with a sinusoidal rise to a relatively low maximum value. Change from acceleration to deceleration is sinusoidal to prevent impact and vibration. The cam has one or more tapered ribs, depending on number of stops required per revolution. Tapering cam ribs makes it possible to use standard precision ball bearings for followers, and to preload the bearings to remove backlash by decreasing distance between shafts of cam and follower. Rib contours are generated on a special milling machine and are always in contact with 2 rollers. In dwell position, followers are locked in place by straight portion of cam rib. Portions of cycle time used for dwell and motion are set independently from number of stops per revolution of the cam.

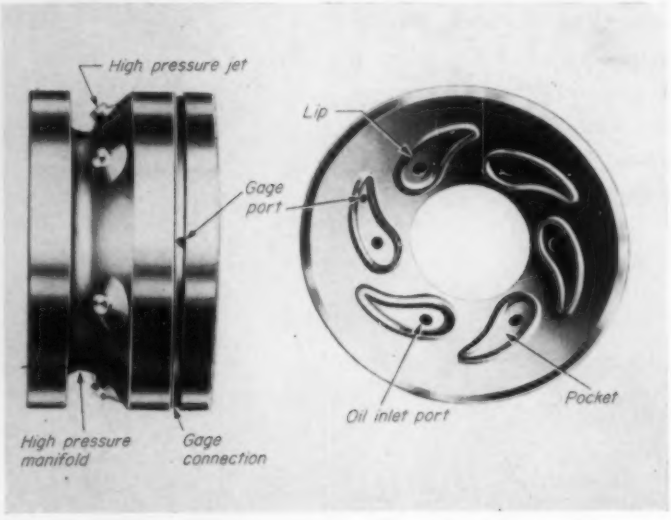


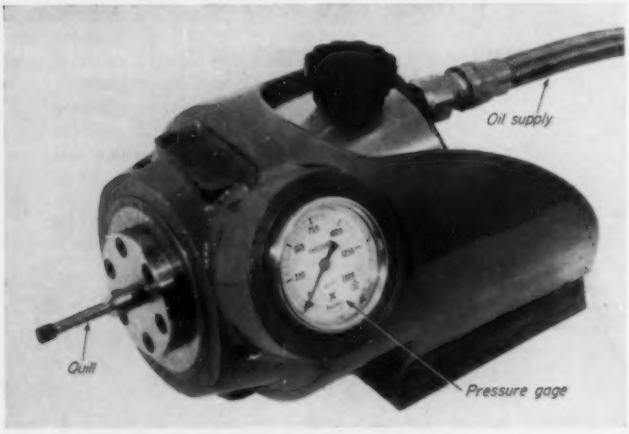
PEAK ACCELERATION VALUE is much lower than that of 3 and 4 position geneva drives. Also, change from positive to negative acceleration is less rapid with no abrupt change at start and end of motion. Cam drive overcomes speed limitations of ratchet and geneva indexing devices by keeping dynamic forces low. Lack of vibration in cam driven table reduces wear and allows indexing tolerances of 0.0015 in. to be obtained on a 36 in. dia table, with the cam operating at speeds up to 300 rpm.

Hydrostatic Bearing Supports Thrust and Radial Loads

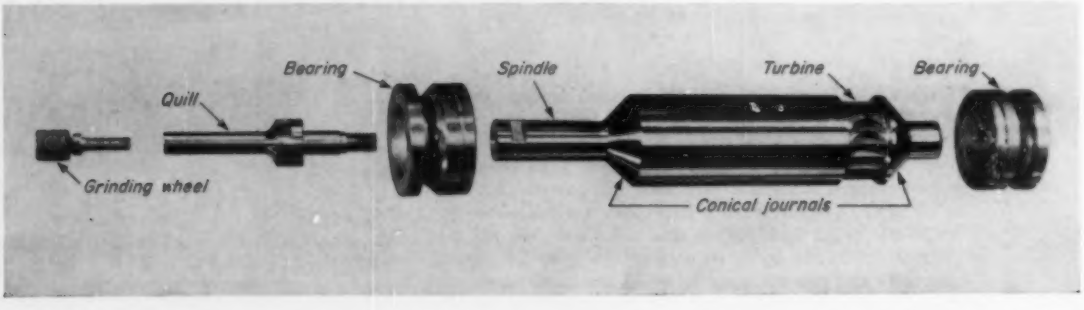
High pressure oil is forced through pockets on a conical surface to make a combination journal and thrust bearing which develops large restoring forces at high speeds. Used on a grinding head made by Reilly Engineering Ltd., Guildford, Surrey, England, this hydrostatic bearing keeps spindle deflections within 25 micro in. when making heavy cuts. To avoid spindle vibration, driving torque is obtained from hydraulic jets which impinge on turbine buckets in spindle.

POCKETS ON BEARING SURFACE ride on conical journals at each end of the spindle with total axial clearance of 0.001 in. Lips on pockets are about 0.015 in. wide and are lapped to mate with the journal surface. Oil enters each pocket through a high pressure jet and escapes through the orifice formed by clearance between lip and journal. A gage connection in one pocket indicates pressure variations caused by spindle deflections. Pressure in pockets varies with ratio of supply jet and exhaust orifice areas and is the same in each pocket when the unit is running without load. When the spindle is deflected, variations in lip clearance change oil pressure in the pockets to develop a restoring force. Oil is supplied to jets at pressures between 1500 and 3000 psig and normally held at half the supply pressure in the pockets. Higher pocket pressures are used to obtain greater restoring forces in applications where spindle rigidity is critical.

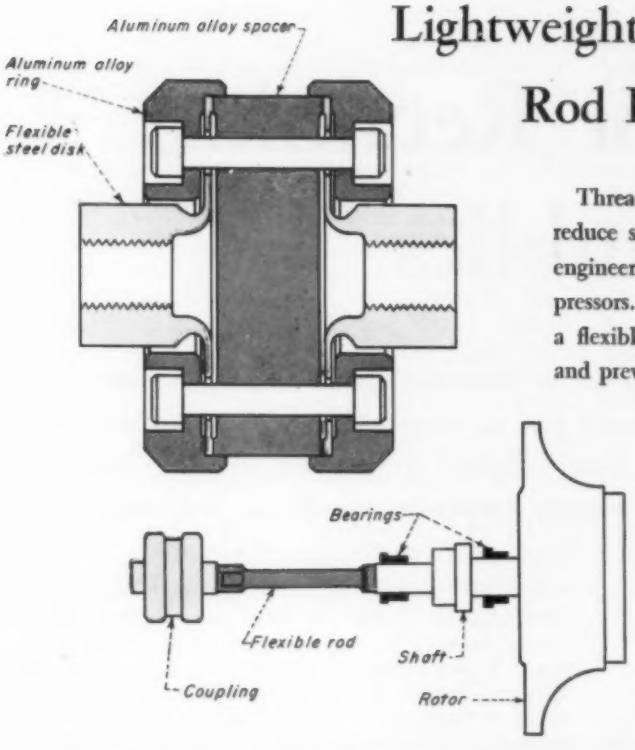




SPINDLE IS DRIVEN at speeds up to 120,000 rpm by an integral hydraulic turbine wheel; side thrust is avoided by using two diametrically opposed jets. Turbine drive and hydrostatic bearings prevent spindle vibrations as there is no mechanical connection to external disturbances. Collection of exhaust fluid from turbine and bearings was a major development problem as spindle diameter had to be small for interchangeability with existing units. Solution was to use excess kinetic energy of fluid and tear-drop shape of pockets to pump oil to discharge port. Oil filtration is critical factor which determines life of spindle. As running parts do not touch, life is indefinite unless filter failure clogs jets or damages lips on pockets. Special interchangeable quills have been designed to hold unbalance runout to 0.0001 in.



Lightweight Coupling and Flexible Rod Reduce Rotor Vibration



Threaded shaft connections and aluminum alloy parts reduce size and weight of flexible coupling designed by engineers at York Corp. to drive their centrifugal compressors. Connecting coupling to compressor shaft with a flexible rod reduces transmission of torque pulsations and prevents local fatigue failures in the rotor.

HIGH FREQUENCY PULSATIONS from minor imperfections in gears of speed increaser cause local resonant vibrations in the rotor. Fatigue failures are prevented by using the flexible rod to reduce amplitude of pulsations transmitted to rotor; rod diameter is small as it does not support weight of coupling. Coupling is made by clamping edges of flexible steel disks between aluminum rings and spacer. Threaded connections use no keys; hubs can be small and light. Hub and disk are machined from bar stock. See December 1956, page 154.

Saw carriage travels on a cross beam above the ingot in an automatic hydraulic saw, made by Loma Machine Manufacturing Co., Inc., to keep chips and cutting fluid out of the drive mechanism.

Bonding cast iron cylinder sleeves to a cast aluminum engine crankcase reduced distortion in the sleeves which only became noticeable after several hundred hours operation. D. W. Onan & Sons, Inc., Minneapolis, Minn., who make the engines, found heat treating the casting prior to engine operation did not help.

Tail lights of the Studebaker half-ton pick-up are held in position by springs. They deflect forward on pivots, when backed into an obstruction, and avoid damage.

Rapid-indexing controls and extensive spindle motion on the new Lahr deep hole drilling machine make layout and drill jigs unnecessary.

Tunnels cast in the column of a rotary gear shaving machine make space for flush mounted push button control panels. Made by National Broach and Machine Co., Detroit, Mich., the unit also has a separate cutter drive gear box in top of the column.

Adjustable uniform rates of acceleration and deceleration, and a 30 to 1 regulated speed range are in a static speed regulating control system developed by General Electric Co. for sectional paper machines.

To avoid forming chain chords on finished work pieces, a timing belt is used to drive the reciprocating table of a precision surface grinder made by Reid Brothers Co., Inc., Beverly, Mass.

Magnesium extrusions form the frame-work of a truck body made by Metropolitan Body Co., Bridgeport, Conn.

Die cast brush backs for the agitators of upright electric cleaners, made by the Hoover Co. of North Canton, Ohio, are cold formed to a helical contour after the bristles are anchored in cored holes.

Brakes of new Hyster Co. lift trucks are self energizing in both directions.

Ductile iron dies are used to draw and form stainless steel sheets without damaging the finish at Norris Dispensers Inc. of Minneapolis, Minn.

By measuring the depth of penetration of a tapered needle-like contact, Federal Products Corp., Providence, R. I., gages jewel bearings too small for an ordinary gaging contact.

Point opening is adjusted while the engine is running in an inverted design distributor used on 1957 GMC trucks.

Transmission gears are tested for excess noise at various speeds automatically, in a machine made by Michigan Tool Co., Detroit, Mich. Multiple-gear clusters can be tested.

Nylon bearing inserts are molded in phenolic plastic housings for the ice making mechanism of the Servel automatic ice server. The thermoplastic insert was molded in the thermosetting material by hicago Molded Products Corp.

Grooves for Retaining Ring Assemblies

Function of the groove in various kinds of ring applications; relation of the retained part to the groove; how to cut grooves properly. Common faults in groove cutting, what effect improper grooving has on the assembly and how the assembly may be salvaged.

HUGO WURZEL
Chief Design Engineer, Truarc Div., Waldes Kohinoor, Inc.

RETAINING RINGS used to secure machine components in housings and bores generally are seated in grooves which lock the rings in position and provide the assembly with a calculated thrust load capacity. Because the groove is a vital part of the fastening system, the importance of proper groove location and cutting cannot be overemphasized.

The function and characteristics of retaining ring grooves differ according to ring types. The groove suggested for standard and inverted rings is illustrated in Fig. 1. It is rectangular in cross section and should be cut so that the walls are at 90 deg with the axis of the shaft. In a typical assembly thrust loads are transmitted from the retained part to the ring and, in turn, from the ring to the groove wall. As a consequence, the strength of the groove material and the amount of contact area between ring and groove wall determine to a large degree the assembly's thrust capacity.

Grooves for beveled rings, shown in Fig. 2, have a beveled wall matching the bevel of the ring. The standard bevel angle is 15 deg. In some cases, however, where friction between the ring and groove wall is reduced, as would happen when oil is used, the angle is reduced to remain within the angle of repose. The beveling works in conjunction with the ring's spring properties, permitting internal rings used in housings and bores to expand in the groove and external rings, used over shafts, to contract in the groove. This expansion or contraction brings the ring into close contact with the retained part, automatically compensating for accumulated tolerances and variations in manufacture, and providing a rigid assembly free of end-play. Once again, maximum contact area and groove strength are essential for optimum performance.

Bowed rings require grooves similar to those used with standard and inverted types. The groove generally is cut wider, however, as illustrated in Fig. 3, to permit the ring to have a maximum of resilient end-play take-up. The groove must be wide enough to accommodate the bow height of the ring within its take-up capacity.

For optimum ring performance, the abutting face of the retained part should be straight and have sharp

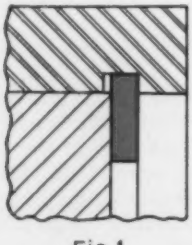


Fig. 1

Fig. 1—Standard groove and assembly for an internal retaining ring. Groove walls should be in a plane perpendicular to the shaft axis.

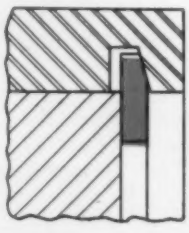


Fig. 2

Fig. 2—Beveled retaining ring is used to take up end play caused by manufacturing tolerances. Ring expands along the 15 deg slope until wedged.

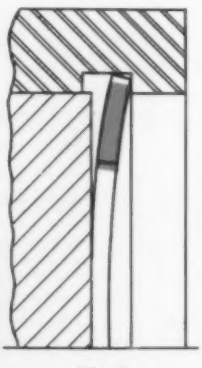


Fig. 3

Fig. 3—Boxed ring groove is somewhat wider than the equivalent standard ring to free the ring for end play flexure.

corners. Loads then will be transmitted as close as possible to the groove wall, using the full thickness of the ring to resist shearing and provide maximum uniform compression loading for the groove wall.

If the abutting face is curved and the resultant of the forces is transmitted from the machine part to the ring at a distance from the groove corners the ring will tend to dish under the forces and the groove wall will not be loaded uniformly. The result will be a reduction of the ultimate thrust capacity. A similar situation exists where the abutting face has corner radii or chamfers.

For straight rings the groove must be straight and should have sharp corners at the top. Corner radii at the bottom of the groove are recommended within limits to facilitate groove cutting and reduce stress concentrations. Grooves that are to be loaded unidirectionally may have increased groove widths but the location of the loaded groove wall should be calculated carefully to obtain minimum clearance between the ring and the face of the retained part. If cycle loading is present both groove walls must be located accurately.

For beveled rings accurate groove location is mandatory to obtain the desired rigid assembly free of end-play.

Materials

Since the strength of a ring assembly depends not only on the ring but on the strength of the material in which the grooves are cut, it is of prime importance to select the proper material for the required loading conditions.

To determine the strength of the groove wall a number of factors must be considered: the shaft or bore diameter, the depth of the groove, the compression strength of the material in which the groove is to be cut and a safety factor determined by the designer.

Formulas for groove wall strength with various ring types are generally available from the manufacturers. For standard rings having full contact with the groove wall groove strength may be calculated as follows:

$$P = \frac{\pi S d Y}{F}$$

where
P = allowable compression load (lbs)
S = housing or shaft diameter (in.)
d = groove depth (in.)
Y = ultimate compression strength (psi) of groove materials
F = factor of safety

If the allowable compression strength calculated by the formula is lower than the thrust capacity required for the assembly, the groove material is too soft and should be replaced with another material having a higher compression strength.

If this cannot be done and there is danger the groove will be overloaded, it is sometimes possible to save the machine part by cyanide or other methods of surface hardening which will strengthen the groove wall. If the ring properties permit, it may be possible to deepen the groove so as to increase the contact area of the loaded groove wall.

Another solution is to widen the groove and use a ring of increased thickness to reduce the amount of ring deflection and maintain a more uniform load on the groove wall as shown in Fig. 4. If a thicker ring is unavailable two rings of the standard thickness sometimes may be installed, as shown in Fig. 5.

Hardness required for the groove material sometimes poses a problem in assemblies where limited space conditions make it impossible to increase the dimensions of the parts. Installations involving axles and transmission housings are typical examples. In such cases any stress concentrations in fillets or grooves may lead to brittleness and fracturing. Where this happens the parts must be discarded and replaced by others whose tensile strength will withstand the loading requirements.

In some cases it may be possible to widen and deepen the groove and increase corner radii to relieve stress concentrations, as shown in Fig. 6A. Before this is done, however, the ring installation should be analyzed to make certain the necessary load capacities will be maintained.

When the groove material is too hard, relief notches may be added on each side of the groove to soften sharp stress concentration lines. This is illustrated in Fig. 6B. Notches may be used either in shafts or bores.

Groove Dimensions

In all retaining ring installations, groove dimensions should correspond to those suggested by the manufacturer and should be checked against the loading conditions of the individual assembly. The dimensions should be specified clearly in the part drawings to provide the shop with an accurate cutting guide.

Differences between blueprint specifications and the groove actually cut in the part often may be corrected inexpensively so that the parts may be salvaged and a

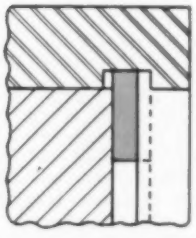


Fig. 4—Increased ring thickness reduces ring deflection under heavy thrust and provides more even distribution of load on groove wall.

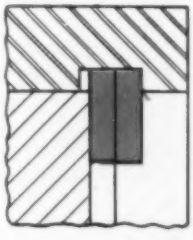
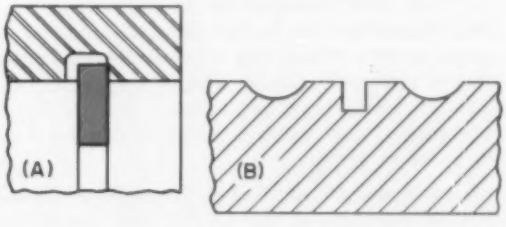


Fig. 5—Two standard rings in a widened groove increase thrust bearing capacity and take up clearance if groove has been cut too far out.

Fig. 6—It is sometimes possible to relieve stress concentrations in grooves cut in materials that are too hard by widening and deepening the groove and adding large corner radii, as shown at (A). Relief notches (B) also may be used to soften stress concentration lines.



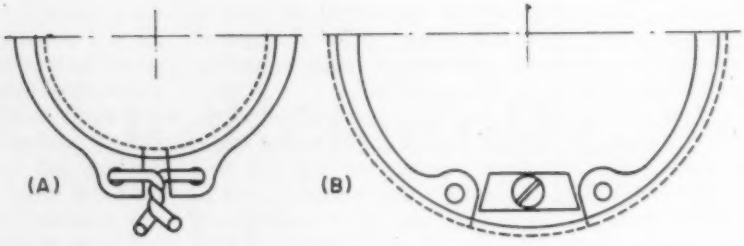


Fig. 7—By wiring the lugs together an overloaded external ring (A) is reinforced in its thrust bearing capacity. An overloaded internal ring (B) is reinforced by filling the space between lugs with a shaped stop. These methods tend to hold the ring in its groove despite heavy thrusts.

satisfactory assembly achieved. Common faults in groove cutting are listed below with suggestions for salvaging the installation.

Groove diameter too small. For external type rings used over shafts the groove is too deep with the result that the ring is seated loosely in the groove. If the increase in groove depth is relatively small and a certain degree of chatter is acceptable, the ring installation may not be harmful to the assembly. If the groove is so deep that it prevents the ring from functioning properly, then remedial measures must be taken.

In many cases the parts may be salvaged by substituting another ring type. For example, a standard external type for a 1 in. shaft often may be replaced by the next smaller size of the inverted external type. The inverted ring's lugs provide the ring with an increased neutral diameter which increases the fastener's spring properties, causing it to fit tightly in the recess in many applications where a standard ring would be too loose.

For the same standard ring it is sometimes possible to substitute an interlocking or crescent ring. In both cases ring configuration, made possible by radial assembly, permits the ring to grip tightly in the deeper groove.

The ring manufacturer should be consulted before any ring substitutions are made, however, to make certain the installation will still have the necessary loading capacity.

With internal type rings, used in bores and housings, if the groove diameter is too small the groove is too shallow, with the result that load capacity is reduced. In some assemblies this may be acceptable so that no change is necessary.

If the load capacity is insufficient, however, then the groove must be made deeper—an operation that may be performed easily in most cases. If for some reason it is impossible to deepen the groove, surface hardening of the groove wall is recommended to increase the strength.

Groove diameter too large:. An external ring groove will be too shallow and should be deepened or surface hardened in the same manner as a shallow groove for an internal ring.

For an internal ring where the groove diameter is too large the groove will be too deep and the ring will be seated loosely. Where this is not acceptable the substitution of a recently available internal ring is recommended. This series has a larger free diameter after installation than the standard series and will provide, within limits a tighter fit in deeper groves.

Groove too narrow. When this happens the ring cannot be assembled in the groove. The simplest solution is to widen the groove to the proper dimension. If for some reason this cannot be done it is often possible to secure rings made of a thinner gauge metal. Thinner rings, however, have a reduced thrust load capacity which must be considered in relation to the application.

If the groove cannot be widened and the thrust capacity of the thinner ring is insufficient for the application. it may be possible to lock the thinner ring in place. In the case of an external type, this may be accomplished by wiring the lugs together as shown in (A) of Fig. 7. Internal rings may be locked by inserting a screw or other type of stop between the lugs, as illustrated in (B). In both cases, surface hardening of the groove wall may also be helpful.

Groove too wide. This generally is not critical if the loaded groove wall is located properly. In some ring applications, however, (reverse loading is one example) the ring would have too much play. One solution is to install a shim washer to reduce the clearance between ring and machine part. Another would be to use a thicker ring which would be available in most sizes. It should be noted that certain types, such as the interlocking ring, work only in grooves of the proper width.

Groove not concentric with bore or shaft diameter. When this happens the groove is too deep on one side, too shallow on the other. The result is an unbalanced loading condition which may or may not be acceptable for the installation. Where the load capacity is insufficient, it is sometimes possible to use a thicker ring to increase the strength of the assembly.

Loaded groove wall not located properly in relation to face of retained part. In the case of straight rings, if the groove is located too far from the machine part there will be excessive end play. If the groove cannot be re-cut, shim washers may be used to reduce the clearance. Another solution is to widen the groove and use a bowed ring to take up the end play.

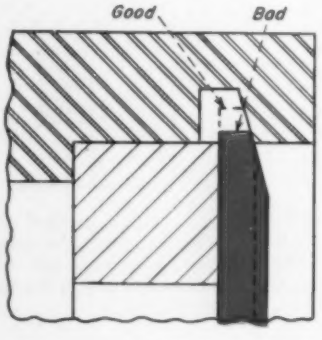


Fig. 8—Improper location of the loaded wall in a beveled ring assembly will take up the play but at a considerably reduced load bearing capacity.

If the groove is too close to the machine part, it will be impossible to install the ring unless a thinner ring is used. If the thinner ring is sufficiently strong for the application but the groove is not, the groove may be strengthened by means of surface hardening.

Problems of groove location for bowed rings are similar to those encountered with straight rings. Location is more critical, however, since free end-play must be eliminated. Where the groove is too close to the machine part a thinner ring once again offers a possible solution.

When using beveled rings, the beveled groove wall must be located properly in relation to the retained part and calculated so that the ring will be seated at a point between the middle of the groove and the groove bottom. When the ring is seated in this manner end-play is taken up rigidly and the assembly will withstand loads to precalculated conditions.

If the outer groove wall is too close the ring will not seat deeply enough in the groove (Fig. 8) and will not take the precalculated load. Where this happens it is sometimes possible to use a thinner ring with a smaller beveled edge.

If the outer groove wall for a beveled ring is too far from the machine part, the assembly will be loose, providing chatter, impact and other unsafe loading conditions. Thicker rings or shim washers offer a possible solution.

Incorrect angle for loaded groove wall. The loaded groove wall for straight rings should be cut at a right angle to the axis of the shaft or bore. If the angle is less than 90 deg, as shown in Fig. 9 (A), the corner of the groove will be overloaded and may break. Whether or not such a groove is acceptable depends upon the loading conditions. In most cases it should be possible to rework the groove to correct the angle.

If the angle is greater than 90 deg the ring may dish and slip out of the groove. Whether or not the groove is acceptable depends upon how much over 90 deg the angle of the load-carrying groove wall is. If the angle does not exceed a right angle by more than 15 deg the groove wall may be acceptable in many installations. If the angle exceeds this 15 deg variation, as shown in Fig. 9 (B), the load capacity will be reduced to a point which, in most installations, will be insufficient. Where this happens the part must be reworked or replaced.

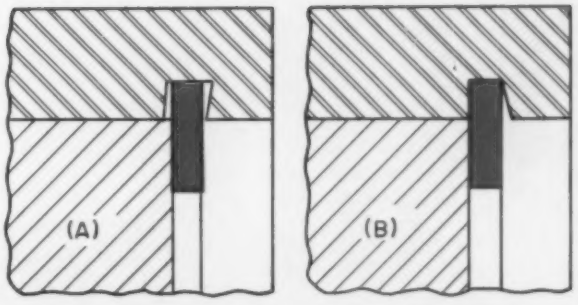


Fig. 9—Loaded groove walls should not be accepted if their slope is more than 15 deg from perpendicular. At (A) the groove corner will be overloaded and may break out. At (B) the retaining ring will dish.

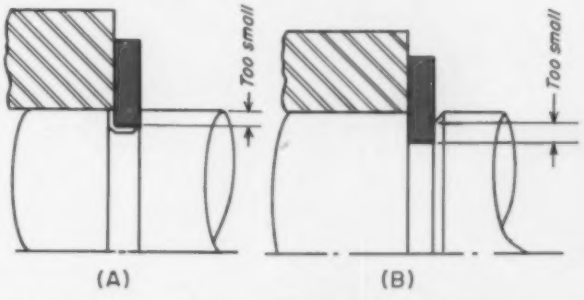


Fig. 10—Extra large bottom radii or chamfered top corners reduce groove wall area for bearing thrust loads.

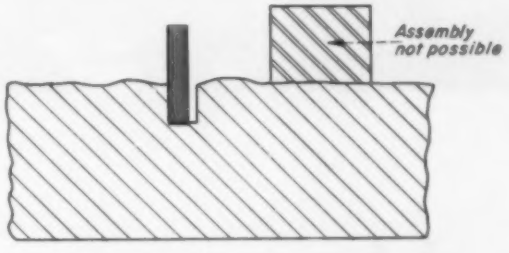


Fig. 11—Metal flow near the groove will interfere with proper assembly of mating parts.

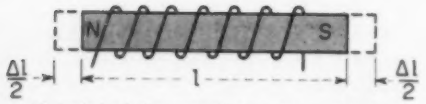
Large corner radii. Sharp or nearly sharp corners at the bottom of the groove are desirable for most retaining ring assemblies provided they do not cause excessive stress concentrations in the machine part in which the groove is cut. In cases where corner radii are necessary, the ring manufacturer should specify the maximum radii allowable.

When recommended radii are exceeded, groove depth is reduced as shown in (A) of Fig. 10 and the strength of the assembly decreased. If the reduced load capacity is insufficient for the application, thicker rings sometimes may be used or the groove may be surface hardened.

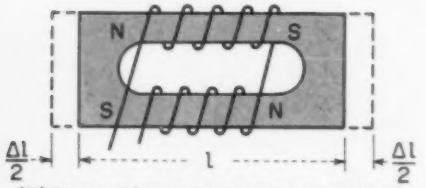
Rounded upper corners. Upper groove corners should be as sharp as possible. If the loaded groove wall is chamfered, has a large radius or is damaged or broken away, bearing area is reduced and the assembly weakened as shown at (B) of Fig. 10. If the reduced load capacity is unacceptable, it may be possible to use a heavier ring, harden the groove wall or deepen the groove to the dimensions of the ring's free diameter. It should be noted that the unloaded groove wall may be chamfered if that is desirable for assembly purposes, as for example, where rubber O-rings are to be installed.

Loose burrs or splinters. These should be eliminated before the ring is installed by means of reaming, lapping, tumbling, etc. If they are not removed they may make it difficult for the ring to be seated or cause damage to sensitive parts.

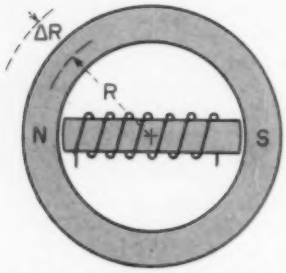
Excessive metal flow around upper groove corners. This will cause distortion to the bore or shaft diameter as shown in Fig. 11. It may prevent the ring from being assembled or make it impossible to assemble mating parts. If the excess metal cannot be removed the parts should be reworked or replaced.



(A) Solid rod transducer. Low efficiency may be improved by laminating bar.



(B) Slotted laminated stock transducer. Equal coils connected to form a low-leakage flux path.



(C) Cylindrical ring transducer. Winding yoke provides circumstantial flux. Vibration is radial.

Fig. 1—Three basic transducers.

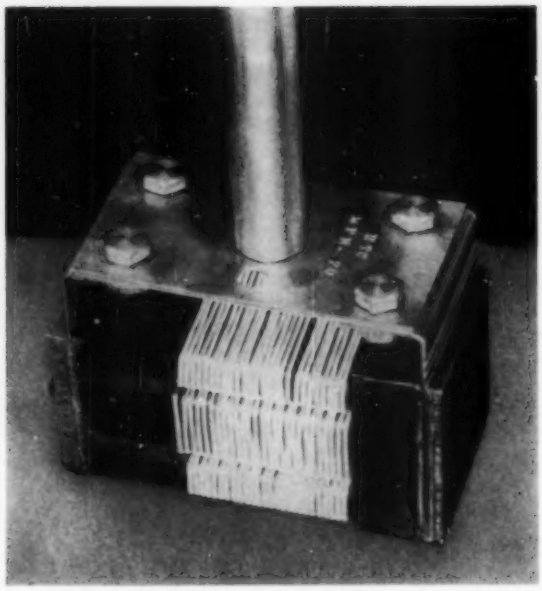
Magnetostriction: A New

MAGNETOSTRICTION is the change in dimension which certain ferromagnetic materials undergo when placed in a magnetic field. It is a reversible process; a change in magnetization occurs when the dimensions of a magnetostrictive material are changed by an external force.

Most devices utilizing magnetostriction are based on the Joule effect —the change in length with magnetization. However, Table I shows three other related phenomena useful for other applications. The Joule effect is generally accepted as the most important and useful because it is the largest in magnitude. This effect provides the design engineer with another method of generating a force or displacement, or both, with magnitude and frequency controllable within wide limits. Where displacement is the basis of design, for example, the motion can be a periodic pulse or it can occur at high frequency.

World War II stimulated the practical applications of magnetostriction. Sonar and related devices for detecting submarines and ships by pulse generation and reflection are perhaps the best known of these uses. Such successful applications have stimulated industrial interest in the phenomenon. Recent developments range from feed mechanisms for machine tools to a new method of welding based on a concentration of energy supplied via magnetostriction.

The magnetrostrictive device or transducer can be made in several forms depending upon the application. Some of the more common types and their characteristics are given in Fig. 1. Of these, the simplest type is a rod (A) of a highly magnetostrictive material such as nickel, excited by a solenoid winding. However, this



A type of magnetostrictive, permanently magnetized, free flooding, corrosion resistant transducer which finds many applications in sonic and ultrasonic industrial processes.

Table I—Four Magnetostriction Effects

Joule Effect	A change in length of a ferromagnetic material along the axis of the applied magnetic field, when the strength of this field is changed.
Villari Effect	Magnetization of a ferromagnetic material is changed upon the application of stress to the material.
Wertheim Effect	If a wire is placed in a longitudinal magnetic field and twisted, there is a transient voltage difference between the ends of the wire.
Wiedemann Effect	Twist or torsional stress will be produced in a wire placed in a longitudinal magnetic field and current passed through the wire.

This little known method of converting electrical to mechanical energy generates large static forces or small displacements—at frequencies from zero to ultrasonic. Applications already cover many fields, from soldering and welding to oil well drilling. Materials, performance characteristics, design factors and applications.

Design Tool

EDMUND M. WISE, Ph. D.
Assistant to Vice President
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form is limited to low frequency applications if high efficiency is sought. The laminated stack type (B), though somewhat more complex in construction, has lower eddy current losses and other advantages. In some instances, it may be possible to further simplify and improve a design by having a structural element serve as the core.

General Characteristics

Compared with other methods of converting electrical to mechanical energy, the magnetostriction transducer has several advantages:

1. Ability to drive high impedance loads, such as liquids and solids.
2. Durable construction, similar to a transformer. Not likely to be damaged by periodic overloads, loss of cooling, or neutron irradiation.
3. Operates efficiently under difficult environmental conditions, such as high temperature, moist or corrosive atmospheres, dirt, water immersion, and large hydrostatic pressures.
4. Adaptable to wide range of sizes and power ratings.
5. Efficient operation in a frequency range (5 to 100 kc) where other transducers are relatively inefficient or difficult to construct.
6. Design flexibility. In addition to different core shapes, windings may be selected to use a wide variety of current or voltage levels. May be easily mounted on metal parts.

Performance

Factors that determine the magnitude of the force generated by a magnetostriction transducer, and the amplitude and frequency of the displacements, include: core material, service temperature, dynamic strain, losses and configuration of the transducer.

MATERIALS. Metals which exhibit magnetostrictive effects of practical proportions include nickel, cobalt, and certain alloys of these metals. Nickel exhibits one of the largest magnetostrictive length changes, about 30 parts in one million for a nonrestrained body magnetized to saturation. Thus, a nickel rod one foot long would decrease in length 0.00036 in. Constrained at both ends, this bar would develop a static stress of about 1000 psi.

Comparative data for the magnitude and sign of longitudinal changes in nickel, iron and cobalt are given in Fig. 2. Iron expands in a low strength magnetic field and contracts in a high strength field, limiting its usefulness in many magnetostriction applications. Nickel contracts under all conditions as does annealed cobalt, although the effect is small with cobalt. The behavior of cast cobalt is somewhat questionable.

Considering all factors, pure nickel and the nickel-iron alloys are among the most useful of all magnetostriction materials. Although iron shows both positive and negative changes in length, the addition of a few per cent nickel results in positive changes for all field strengths. More important, as shown in Fig. 3, the peak of the positive magnetostriction occurs at about 45 per cent nickel. This peak value compares favorably with that of pure nickel when this factor alone is considered. The 63 per cent nickel alloy is the most strain sensitive, that is, has the greatest change in magnetization for a given change in stress.

At about 30 per cent nickel, longitudinal magnetostriction drops to zero (this composition is also nonmagnetic at room temperature). At 81 per cent nickel, the curve again passes through zero and at higher nickel contents the changes in length are negative, reaching a peak value at pure nickel. This, combined with the inherent corrosion resistance and substantial fatigue strength, have resulted in the use of pure nickel in most of the applications to date. Where fatigue strength must be further increased, Dura-nickel or one of the cobalt-iron alloys should be considered.

Volume changes have a different relationship to composition than the longitudinal changes referred to in Figs. 2 and 3. The change in volume is a maximum in alloys containing about 36 per cent nickel. Invar, for example, derives its low thermal expansion from this effect: loss in magnetization with increasing temperature alters the magnetostrictive effect and thus nearly neutralizes the thermal expansion.

Since magnetic and magnetostrictive properties of a metal will be affected by changes in its internal structure, it may be necessary to specify heat-treatment procedures. In the case of nickel, a soft anneal generally gives best magnetic properties, but the soft

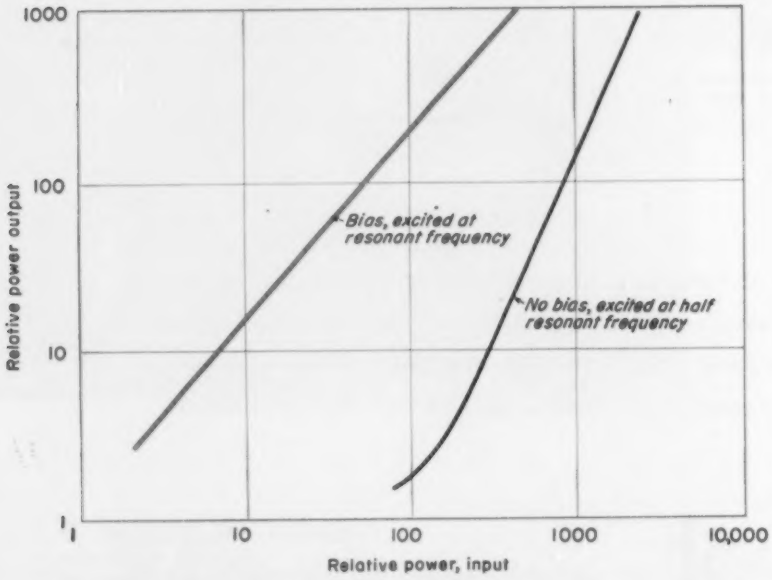

Fig. 2 (above) — Magnetostrictive change in length per unit length of three metals in magnetic fields of varying intensity.

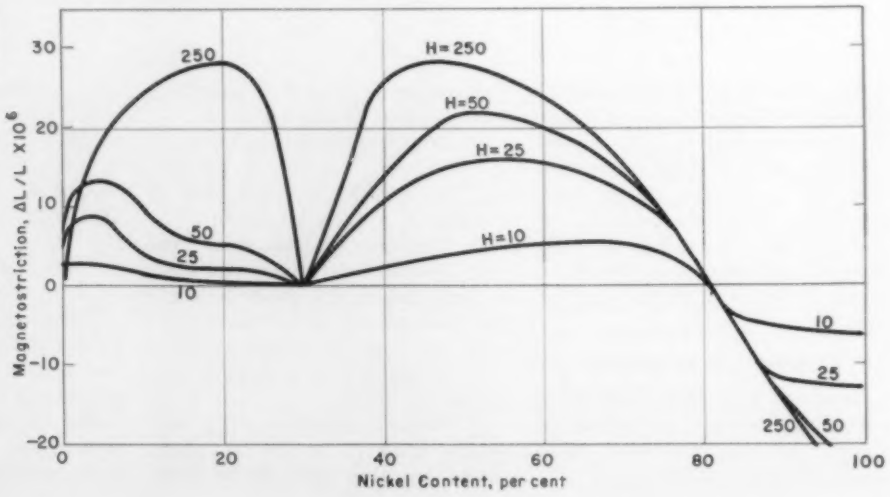

Fig. 3 (right) — Magnetostriction effect in nickel-iron alloy system. Note peak change in length at about 45 per cent nickel.

metal is difficult to punch for laminated construction. Quarter-hard material is preferred for punching and the punched parts are annealed subsequently. An anneal may be specified to develop maximum magnetostrictive properties; however, annealing reduces strength and a balance may be necessary between acceptable magnetic and mechanical properties.

TEMPERATURE. As the operating temperature increases, ferromagnetic alloys lose their magnetism, and thus their magnetostrictive properties. At the "Curie" temperature, these properties are zero for all practical purposes. Thus, for elevated temperature service, a material with a high Curie point must be used. Data for the effect of temperature on the magnetostrictive effect for nickel are given in Fig. 4. Curves for other ferromagnetic metals have the same general shape, with 50 Ni-50 Fe remaining magnetic up to 520 C, and cobalt to about 1130 C. As a result, Co-Ni or Co-Fe alloys are generally used in elevated temperature applications.

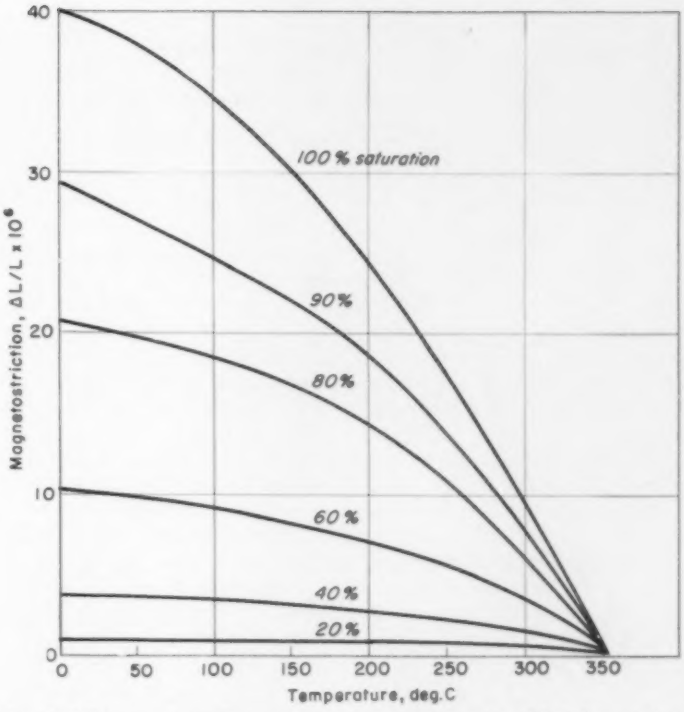

Fig. 4—Influence of temperature on magnetostriction in nickel for various degrees of magnetic saturation.

LOSSES. Mechanical and magnetic hysteresis losses and eddy current losses often determine the permissible operating level of a magnetostrictive device. These losses will be determined to a large degree by the size and shape of the core as well as the material. For maximum efficiency, the laminated type construction is generally recommended. Eddy current losses increase approximately as the square of the frequency and thickness making the rod type inefficient at high frequencies. A thin tube will have lower losses than a rod, but power capacity is also lower. Stacked and insulated laminations about 0.010 in. thick are useful up to about 30,000 cycles; approximately 0.003 in. laminations are preferred at higher frequencies. Above about 50,000 cycles, however, the thickness (as well as length) may be reduced so far as to make construction difficult.

Efficiency may vary from 90 per cent for a well-designed power type unit to 30 to 65 per cent. Where maximum efficiency is required, magnetic bias should be provided. For example, the curves in Fig. 5 compare the performance of a typical low power unit with and without bias. This bias can be supplied by a permanent magnet, by a separate d-c supply, or by the d-c component in the plate circuit of the driving amplifier.

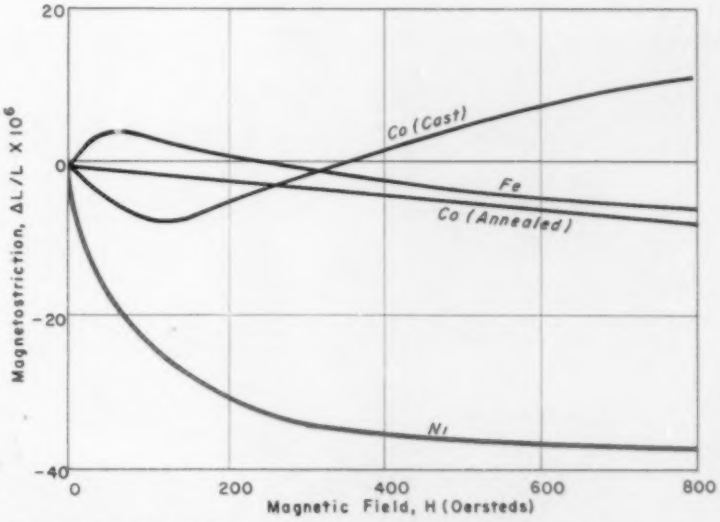

Fig. 5—Magnetic bias increases output of magnetostriction transducers.

ALLOWABLE STRAIN. Allowable magnitude and frequency of displacements for a given material depend upon its fatigue strength. However, the maximum operating stress must be considerably lower than the nominal endurance limit, since the useful life of a transducer involves many more cycles than are normally encountered in mechanical design. Whereas 10^7 or 10^8 cycles is generally considered as infinite life for a mechanical component, 10 hours of transducer service at 25 kc would involve almost 10^9 cycles. In addition, a trans-

ducer core is not an ideal structure from the standpoint of fatigue. Sharp edges, changes of section, and welded joints between dissimilar metals create stress raisers. A practical operating stress for an annealed laminated nickel transducer core is 10,000 psi. This corresponds to a maximum strain of about 350 microinches per inch or higher.

DESIGN. Operating frequency is as important as transducer geometry. Although a unit may operate over a range of frequencies, it is generally most practical to design for resonance operation. Under ideal conditions, the only energy required for resonant operation is for offsetting the losses and supplying the load on the transducer. The mechanical power generated in a transducer is directly proportional to the dynamic strain level.

Standard commercial equipment can be used to supply the current for generating the magnetic field. The actual field strength required will depend upon the material used. For nickel, 100 oersteds is a nominal value although it is possible to operate at 50-200 oersteds for nickel as well as for Permendur, 45 Permalloy and several other of the more commonly used materials.

Applications

Although industrial applications of magnetostriction are a comparatively recent development, several significant examples are already in industrial use. Perhaps the best known of these are in the field of cleaning and degreasing of metals. Here electrical energy is converted to mechanical vibration which causes cavitation in the cleaning fluid, producing an efficient erosive action that can reach sharp corners and otherwise inaccessible areas.

Another significant development, announced recently, is the welding of similar or dissimilar metals by vibratory energy produced by magnetostriction. Pieces to be joined are clamped between two elements and intense vibratory energy is introduced from a transducer; result is a solid-state metallurgical bond, with low deformation and no fusion. This method is particularly useful in joining very thin sheets to heavy sections, a difficult task with fusion welding.

In the soldering field, magnetostriction makes it possible to solder without flux, thereby reducing the possibilities for corrosion and contamination. A magnetostrictive transducer which delivers high frequency vibratory energy is designed into a soldering gun equipped with a heated tip. This energy is transmitted to the soldering tip causing cavitation in the molten solder which mechanically breaks down the oxide film and permits the solder to wet the base metal. Aluminum, a metal having an unusually tenacious bond, may be soldered with this technique.

An equally interesting and important application involves the use of magnetostriction in a machine tool feed device, Fig. 6. A solenoid winding is wrapped around a bar of nickel several inches long. Clamping the bar at either end alternately and turning the current on and off results in an inching motion that is used to feed a workpiece into a grinding wheel. Increments in the order of a few millionths of an inch are possible.

An oil well drilling unit now under development utilizes a nickel core weighing over 1 ton, demonstrating that size is not a limitation in application of the magnetostriction principles. This device utilizes vertical vibration of a heavy bit to crush rock in its path, the particles then being flushed away with drilling mud.

A new application under development is an automotive fuel injection system in which magnetostriction is used to produce pressure pulses that injects fuel into the cylinders at the right instant for firing. Further applications of this method for converting electrical to mechanical energy depend primarily on the design engineer's ingenuity and his understanding of the phenomenon.

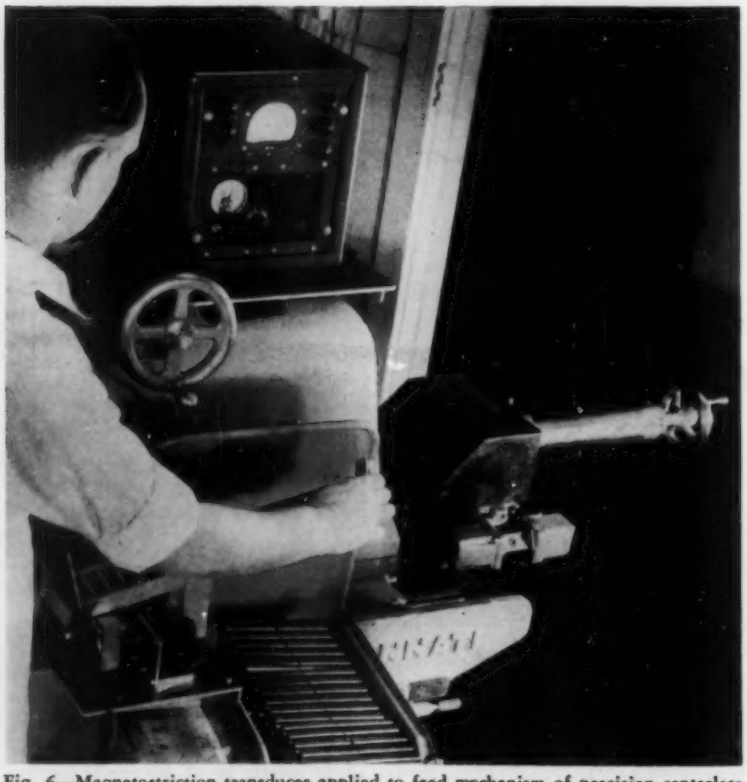

Fig. 6—Magnetostriction transducer applied to feed mechanism of precision centerless grinder. Transducer (at right) provides highly accurate "inching" feed.

EDITOR'S NOTE—Other recent articles on important aspects of magnetic phenomena in product design include the following:

"Ceramic Magnets," December 1956, page 143.

"Fast-Acting Magnetic Clutch," June 1956, page 145.

"Plastic-Bound Magnets," April 1956, page 182.

"Applications for Permanent Magnets," March 1955, page 160.

"Stainless Steel Powder Magnetic Clutches," February 1954, page 142.

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Controlling Temperature Rise

IN SQUIRREL CAGE INDUCTION-MOTOR DRIVES

MOTOR LIFE	Standards for normal life; significance of motor temperature rise and effect of load on motor temperature.
REDUCING MOTOR HEAT	Revising duty cycle using mechanical and dynamic braking; changing motor base speed and reducing load inertia; using high-slip motors.
VENTILATING MOTORS	Improving motor ventilation; cooling motors in restricted spaces and reducing external heat.
OVERLOADING MOTORS	Factors limiting overload; speed-sensitive loads and mechanical limitations.

CHARLES C. LIBBY

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USEFUL POWER OUTPUT and life of a motor are primarily determined and limited by destructive effects of internal operating temperatures on winding insulation. As a result, relationship between actual operating temperature and recommended maximum temperature is a significant factor to be evaluated in selecting a motor.

Proper evaluation of heat produced during duty cycle, time available to dissipate heat, and efficiency of heat transfer from motor windings and housing to air provides the following significant advantages: (1) motor life can be increased or adjusted to requirements; (2) for a given duty cycle a smaller, lighter, or more economical motor may be used with full life expectancy; (3) number of starts and reversals may be increased without increasing frame size, motor hp, or temperature rise; (4) increased hp load can be compensated for without changing motor size or ventilation; and (5) motor weight or size can be reduced without increasing temperature rise or reducing hp rating.

Motor Life and Winding Temperatures

DURATION OF MOTOR LIFE is directly governed by operating temperatures of stator windings. This temperature is the sum of ambient temperature and maximum motor temperature rise. Relationship between life expectancy and operating temperatures of motors with class A and B insulations are shown in Fig. 1, with curves based on deterioration of insulation solely by elevated operating temperatures. These curves are valid if the motor enclosure is selected to properly protect the winding from airborn contaminants, if lubrication system is properly designed and serviced, and if provision is made to prohibit accumulation of moisture in the winding insulation.

Points of 100 per cent life, indicated by the intersection of the *A* and *B* curves with the vertical colored line, correspond to an estimated 20 years at maximum operating temperatures of 95 C for class A and 115 C for class B. These temperatures correspond to NEMA standards which recommend, in a 40 C ambient, maximum temperature rises limited to 55 C for class A and 75 C for class B. Motor winding temperatures shown in Fig. 1 and in following illustrations are based on temperature measurements taken by thermometer, as described in box entitled: "Motor Temperature-Rise Measurement".

Life of a polyphase induction motor can be considered ended when winding insulation fails because cost of rewinding is roughly one-half of motor value. Bearing life is also determined to a more limited extent by effect of motor temperature on bearing lubricants. Within range of temperatures shown in Fig. 1, life expectancy is not seriously reduced. Motors operating in the class B range of temperatures use bearing lubricants which are designed for the increased temperatures.

Motor Temperature Rise

Choice of proper temperature-rise rating for a motor is limited by ambient temperature in which motor is to be operated. For example, variation of stator winding temperature with change in ambient, for motors of standard NEMA temperature-rise ratings of 40, 50, 55, 70, and 75 C, is shown in Fig. 2; it is assumed the motors have been operated under continuous full-load until temperature has reached a stable maximum value.

Ambient temperatures refer to temperature of air in contact with heated motor. The actual ambient may be higher or lower than maximum allowable value of 40 C on which limits of total temperatures are based in NEMA standards. However, temperatures above 40 C limit possible applications, while those below 40 C expand them. Ambient temperatures below 10 C are considered special and may require modification of the motor lubrication system.

Ambient temperature must be added to the rated motor rise to be certain that motor operating temperatures do not exceed maximums of 95 C for class A insulation and 115 C for class B. For example, from Fig. 2, a 40 C rise motor with class A insulation can be used in a 50 C ambient to produce motor temperature of 90 C; but a similar 50 C rise motor could not be used in the same ambient without exceeding maximum allowable temperature by 5 C. If it were necessary to use the 50 C rise motor, class B insulation should then be specified.

MOTOR TEMPERATURE-RISE MEASUREMENT

Two standard methods of measuring squirrel cage induction-motor temperature rise are: use of a thermometer or by calculation from change in resistance of the stator windings. The method chosen usually is the one most convenient, although other factors, such as the inability to remove a motor endbell, may govern the choice.

Maximum temperature limits, in Centigrade, are established by NEMA Standard MG 1–4.16 for various enclosures and types of insulation, as measured by both thermometer and resistance change. Two sets of temperature readings are given because temperatures obtained by resistance measurement are higher than thermometer readings for the same motor temperature. However, corresponding temperatures are directly related in the standards. All listed temperatures refer to values obtained after the motor is operated until temperature has reached a stabilized value, usually after two hours or more.

Detailed information on these measurements appears in "The American Standard Test Code for Polyphase Induction Motors," ASA publication C50.20-1954 and AIEE publication No. 500 B.

Thermometer measurements are most accurate when obtained from that portion of the stator windings extending beyond the core; the thermometer bulb may be affixed to the stator coil using putty. If the motor must be stopped before reading the winding temperature, it is important that the reading be taken as quickly as possible. If temperature is to be read without disassembling the motor, a hole for the thermometer may have to be drilled in the motor end bell.

A simpler, but less accurate method frequently used is to remove the motor lifting ring, fill the hole with lubricating oil, and insert the thermometer. In absence of a lifting ring the thermometer may be affixed to exposed stator core laminations with putty.

Motor temperature rise is obtained by subtracting room temperature from motor temperature. Thermometer readings usually rise for a short time after the motor is stopped, but the initial value should be used.

Resistance measurement is more accurate than thermometer, but requires a resistance bridge or ohmmeter. The formula usually employed for calculating temperature of a motor with copper windings is

$$T_W = \frac{R_2\ (234.5 + T_R)}{R_1} - 234.5$$

where T_W is motor temperature in C; T_R is room temperature in C; R_1 is average resistance in ohms, as measured between stator leads with motor at room temperature; in a 3-phase motor, resistance is measured between leads T_1 and T_2, T_3 and T_2, and T_1 and T_3. And R_2 is average resistance of the same windings after motor temperature has stabilized under intended load.

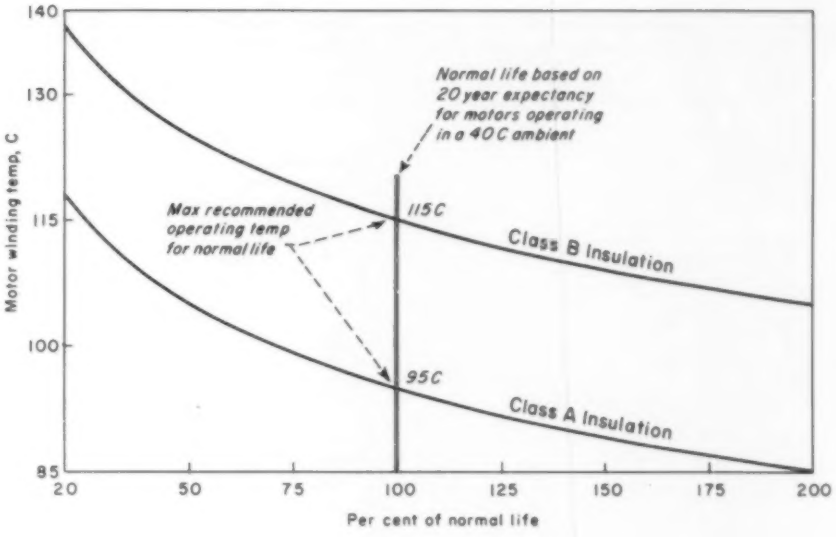


Fig. 1—Effect of motor operating temperature on expected motor life; primary factor is destructive effect of elevated operating temperatures on winding insulation. Operation of motors at higher than NEMA maximum recommended temperatures can give increased performance at cost of decreased life. An expected life of 20 years is based solely on rate of deterioration of insulation by motor heat; curves are valid when windings are protected from air-born contaminants, moisture accumulation, and motor lubricant.

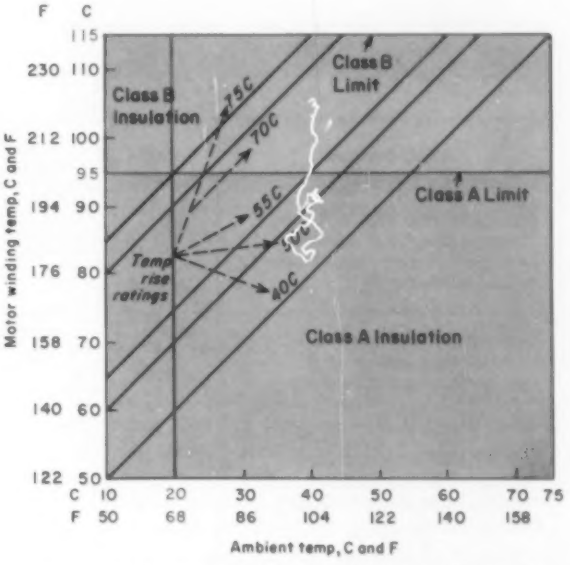


Fig. 2—Ambient temperature in which motor is operated limits choice of temperature-rise rating because normal expected life is decreased if maximum recommended temperature limits of 95 C for class A or 115 C for B insulations are exceeded. Curves show variation in winding temperatures of five temperature-rise ratings as ambient is varied from 10 to 75 C; motors have been operated at continuous full load until temperatures have stabilized. For estimation of motor life, winding temperatures can be compared to those in Fig. 1. Range of normal winding temperatures for class A or class B insulation used on windings falls within shaded areas indicated. Normal room ambient of 20 C is shown in color at bottom of graph. The 70 and 75 C rise motors are normally supplied only with class B insulation. Fahrenheit temperatures are included for comparison.

Temperature-Rise Ratings

Motors of standard and nonstandard temperature-rise ratings can be obtained in one or more types of standard or nonstandard enclosures and frame sizes. Various combinations of NEMA temperature-rise ratings, service factors, and types of insulation for continuous-duty induction motors based on a 40 C ambient are listed in Table I. For special operating conditions, nonstandard combinations of these factors and ambient temperatures, are listed in Table II.

Standard temperature-rise ratings in Table I apply to NEMA Design A, B, C, D, and F motors in standard enclosures. For open drip-proof enclosures, service factors of 1.15, 1.20 and 1.25 are listed, while a service factor of 1.00 applies to Design D in the open drip-proof and to all NEMA Designs in splash-proof, totally enclosed non-ventilated, and totally enclosed ventilated.

The service factor indicates maximum hp which may be obtained from a motor for 100 per cent life, Fig. 1, under continuous load without injurious overheating. For service factors of 1.00, max hp agrees with nameplate rating; for service factors greater than 1.00 max hp is the product of service factor and nameplate rating. For example, a 10-hp motor with a service factor of 1.15 can be applied to a continuous 11.5-hp load without injurious overheating.

In general, service factor of lower-hp motors is higher, since they tend to be overloaded in the type of applications for which they are used. Where load can be exactly predicted, a service factor in excess of 1.00 should not be needed; however, where equipment may be overloaded by user, added capacity of a service factor higher than 1.00 may be useful.

Relationship of service factor to motor temperature rise and motor winding temperatures may be obtained from the curves in Fig. 2. For example, if nameplate rating of totally enclosed fan-cooled motor indicates a service factor of 1.00 and a 55 C rise under continuous full load, actual motor temperature in a 40 C ambient will be 95 C, which is upper

Table I — NEMA Temperature Rise Ratings, Service Factors, and Types of Insulation for Continuous Duty Induction Motors Operating in 40 C Ambient Temperature

Because NEMA Standards do not define service factor of Design D motors, standard commercial practice is indicated. Splash-proof enclosures include semi-guarded, guarded, and drip proof fully guarded. Drip proof motors may also be rated 50 C rise.

Type of Enclosure for NEMA Design A, B, C, D and F Motors 1 to 200 hp	Standard Motors			Special Service Motors		
	Service Factor	Rated Temp Rise, C	Class of Insulation	Service Factor	Rated Temp Rise, C	Class of Insulation
Open or open drip-proof 1. NEMA Design A,B,C,F 1 hp 1½ and 2 hp 3 to 200 hp 2. NEMA Design D	 1.25 1.20 1.15 1.00	40	A	—	—	—
Splash proof, all Designs and hp ratings	1.00	50	A	1.00 1.00	70 110	B H
Totally enclosed and totally enclosed fan cooled, all Designs and hp ratings	1.00	55	A	1.00	75 115	B H

Table II — Nonstandard Combinations of Temperature Rise Rating, Service Factor, Type of Insulation, Frame Size, and Ambient Temperature for Continuous Duty Induction Motors Under Special Operating Conditions

Special Conditions	Enclosure	Service Factor	Rated Temp Rise, C	Type of Insulation	Max Ambient Temp, C	Frame Size
Severe duty cycle, where NEMA standard temperature rise is exceeded for frequent starting, frequent reversing, or heavy-inertia starting	open	1.00	70	B	40	NEMA standard
	enclosed	Same as NEMA, for special service 75-C and 115-C rise motors				
Smaller than NEMA frame size required to reduce space or weight, rotor inertia, or cost of installation	open	1.00	70	B	40	smaller than standard
	enclosed	1.00	75	B	40	
		1.00	115	H	40	
Service factors higher than standard required for intermittent or emergency overloads without injurious heating	open	1.25	40	A	40	larger than standard
		1.25	40	B	40	NEMA standard
	enclosed	1.15	40	A	40	larger than standard
		1.15	55	B	40	NEMA standard
Ambient temp above 40 C when open motors are operated at max load allowed by service factor or when enclosed motors are used	open	1.15	40	B	60	NEMA standard
	enclosed	Same as NEMA for special service 75-C and 115-C rise, except for 60 C ambient				

limit for class A insulation. Under these conditions continuous overload will increase winding insulation temperatures over maximum recommended values and decrease life expectancy as indicated in Fig. 1.

If, on the other hand, an open drip-proof motor has nameplate rating of 40 C rise and a service factor of 1.25, the motor may be run at 125 per cent of rated load in a 40 C ambient without exceeding 95 C for class A insulation. That is, the 95 C rating limit on motor temperature allows for an additional 15 C rise on overloads within the service factor.

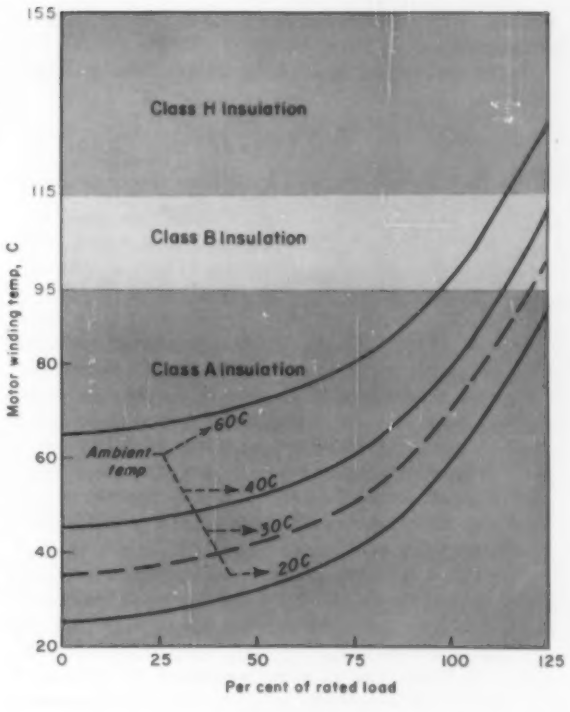
By operating the same 40 C rise motor within its nameplate hp rating, it can be applied in a 55 C ambient without exceeding class A temperature limit.

Nonstandard temperature rise ratings in Table II can be used where a motor must: (1) be chosen for a severe duty cycle, (2) be of smaller frame size than a comparable NEMA frame, (3) operate in ambient temperatures above 40 C, or (4) be selected with a service factor higher than standard.

Effect of Load on Motor Temperature

Ambient temperature in a given application may be higher or lower than ambients on which temperature rises

Fig. 3—Effect of motor load on stabilized winding temperatures for 40 C rise motors in 20 to 60 C ambients. At no-load, winding temperature is approximately 5 C above ambient, but increases with load until at full load it is equal to sum of ambient plus rated temperature rise. Beyond full load, temperature increases rapidly. Dashed 30 C curve pertains to example discussed in text. Graph applies to motors of 1 to 200 hp.



listed in Tables I and II are based. Ambient temperatures below normal may allow overloads beyond service factor guarantees; or higher ambients may preclude use of the guaranteed service factor in order to keep motor temperatures within maximum allowable limits.

Effect of load on motor temperature, at ambients between 20 and 60 C, is shown in Fig. 3 for a 40 C rise motor. Relationship between load, temperature rise, ambient temperature, and type of insulation required for normal life can be obtained from the curves. For example, a 10-hp 1800-rpm 40-C rise motor with class A insulation is specified to deliver 100 per cent continuous load in a machine located in a 30 C ambient. Such operation produces a motor temperature of 70 C, well within class A limits.

However, a revision in the drive requires 25 per cent continuous overload. In this case, motor temperature will increase along the dashed 30 C ambient curve to approximately 100 C, which is outside class A insulation. In this case, class B insulation is a possible solution, provided application allows use of motor with a higher than 40-C rise rating at normal loads. An operating load test and temperature measurement will verify if new motor operates within recommended maximum for class B.

Reducing Motor Heat

ANY REDUCTION IN HEAT produced by an electric motor decreases operating temperature. This decrease may be used to increase normal motor life; or it may make possible use of smaller, lighter, or more economical motor operating at normal temperature and with normal life.

For motors applied in duty cycles involving frequent starting or reversing, motor heat may be reduced by: (1) duty-cycle revision, (2) inertia reduction, or (3) motor Design selection.

For motors operating continuously at a constant load, heat produced is determined by hp output and motor efficiency. For reduction in operating temperature, efficiency may be improved or load reduced; otherwise, any temperature reduction requires that heat be removed by ventilation improvements rather than by duty-cycle revision. Motor ventilation is discussed in a later section.

Duty Cycle Revision

For a drive motor applied in a duty cycle with frequent starts or reversals, starting heat losses are several times higher than those produced by full-load operation; for example, heat produced in starting a NEMA Design B motor with no connected load is 8 to 10 times that produced by full-load operation for same period. In addition, motor ventilation is reduced by lower average speed. These factors combine to increase motor temperature rise. In duty cycles which include 15 or more starts per min, 5 or more plug reversals per min, or 15 or more reversals per min using a brake stop, a significant portion of total heat is produced during these periods.

Heat developed by continuous duty-cycle operation can be most simply reduced by lowering cycling rate. However, to maintain or increase cycling rate, heat can be reduced on the basis of revision within the cycle. Because starts, plug stops, or plug reversals produce most heat, it can be minimized by comparing possible combinations of these duty-cycle elements and revising the cycle by using that combination which reduces temperature rise within minimum or acceptable limits.

To compare starts, plug stops, or plug reversals, heat produced by each duty-cycle element is evaluated in terms of heat produced by a single acceleration.

Total heat produced during a single load acceleration is equal to the sum of rotor heat loss H_R and stator heat loss H_S. Rotor heat loss is

$$H_R = 2.3\ (WR^2)_T \left(\frac{RPM_S}{100}\right)^2 (S_i^2 - S_f^2) \qquad (1)$$

where H_R is heat produced in watt-sec per start; $(WR^2)_T$ is total inertia of motor and load in lb-ft^2; RPM_S is synchronous speed of rotating stator field; $(S_i^2 - S_f^2)$ is slip factor in which S_i is initial motor slip, S_f is final slip, and slip is

defined as: $S=(RPM_S-RPM_M)\ /\ RPM_S$, where RPM_M is rotor speed.

Stator heat loss H_S is a function of rotor heat loss and is equal to

$$H_S=H_R\left(\frac{R_S}{R_R}\right)C_1$$

where R_S is stator resistance, R_R is rotor resistance, and C_1 is a constant determined by electrical design.

Total heat loss H_T is therefore

$$H_T=2.3\ (WR^2)_T\left(\frac{RPM_S}{100}\right)^2(S_1^2-S_2^2)\left[1+\left(\frac{R_S}{R_R}\right)C_1\right] \quad (2)$$

A study of Eq. (2) indicates that, for a given motor and load, all terms are constants except the slip factor; consequently, heat produced is proportional to this factor, which is equal to 1 for a single acceleration from zero to synchronous speed—to 3 for a plug stop from full speed—and to 4 for a full plug reverse (plug stop plus acceleration). That is, heat produced in one plug stop is equal to three times that of a single acceleration; and for a plug reverse, heat is four times.

Although slip-factor values indicate relative heat produced, they are not used directly for duty-cycle revision because the life of the motor depends not on heat produced, but on temperature rise. Therefore, "corrected slip-factors", shown in Table below, have been derived in terms of amount of heat which will produce the same temperature rise if one element of a duty cycle is numerically equated to the other. For example, 3 accelerations will produce same temperature rise as 1 full plug reverse, or 2 accelerations will produce same rise as 1 plug stop. These corrected values are used in following examples of duty-cycle revision.

Duty-Cycle Element	Slip Factor $(S_1^2-S_2^2)$	Corrected Slip Factor
Acceleration from zero to synchronous speed	1	1
Plug stop from full speed	3	2
Full plug reverse (plug stop plus acceleration)	4	3

Using Mechanical Brakes

Heat produced in the plug stop portion of a duty cycle can be eliminated by substituting a mechanical brake stop; this may allow motor size to be reduced. Example in Table III compares plug reversals with mechanical brake stop substituted for plug stop. Here, a NEMA Design D 50 C rise motor with class A insulation was satisfactorily used to obtain 500 reversals an hour, but when 700 were specified, heat produced was too much for the motor and a NEMA D with a special stator, class B insulation, and temperature rise of 75 C was specified. However, revising the cycle by using a mechanical brake for stopping reduced motor temperature sufficiently to permit use of the original NEMA D motor for 700 reversals.

Mechanical-brake features generally govern selection for a particular application. Spring-applied, electrically released brakes stop motor and load and hold both immobile between operations. Electrically applied spring-released brakes require added electrical control equipment, but make possible a combination of brake and clutch in limited space.

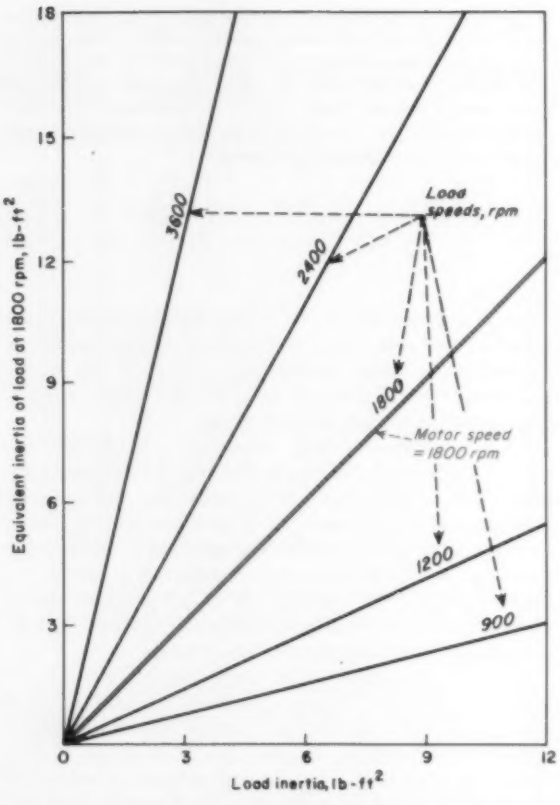


Fig. 4—Reduction in load speed reduces temperature rise by lowering effective load inertia at motor shaft. Variation of equivalent load inertias for five load speeds, each referred to 1800 rpm of motor; reduction in effective load inertia is proportional to the square of the ratio of load speed to motor speed.

This permits motor to continue rotating and only load to be stopped, further reducing temperature rise.

Dynamic braking by applying d-c to motor winding after a-c power is disconnected can be substituted for mechanical braking or for plug stopping. A single stop by dynamic braking produces as much motor heat as one start with the same inertia. However, it requires, as does plug-stopping, addition of a control element to sense or predict the instant at which the motor stops.

Changing Motor Speed

Heat produced in accelerating or plugging operations is proportional to the square of maximum or synchronous motor speed, from Eqs. (1) and (2). Consequently, it may be practical to use lower motor rpm with a higher gear or V-belt drive ratio, and thus produce net reduction in heat for frequent starts or reversals. For example, a 900-rpm motor can reverse four times as frequently as an 1800-rpm motor with same production in heat, provided inertia is the same. An increase in inertia occurs because of increase in frame size of lower speed motor; this decreases advantage of the lower speed motor, but in all cases, lower speed produces less heat during acceleration than the high. In addition, larger frame size of lower speed motor tends to improve heat dissipation and further reduce motor temperature. This

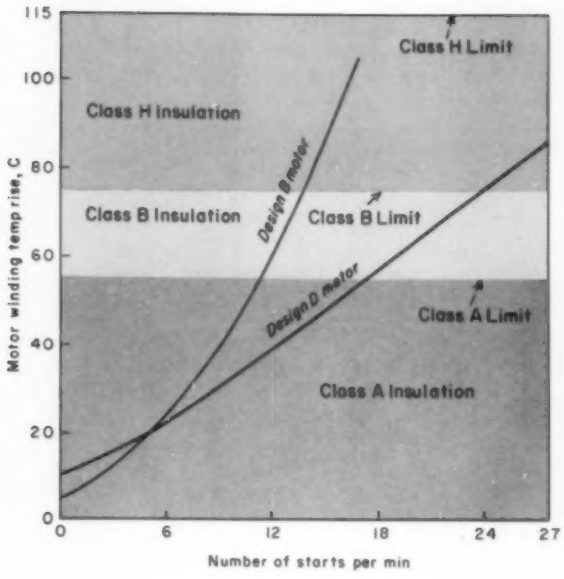


Fig. 5—Selection of proper motor Design type can reduce temperature rise for duty cycles with frequent or long periods of acceleration. Curves shown apply to NEMA Design B and D motors, 1800 rpm, 1 to 25 hp. Temperature rise shown is based on inertia load only; constant running load is not considered. For less than 5 starts per min Design B motors have lower temperature rise, but over 5 starts advantage of Design D motor increases with starting frequency.

factor is discussed in greater detail under "Ventilating Motors."

Reducing Inertia

Another important means of reducing motor heat is to reduce load and motor inertia, where possible, since heat is reduced in the same proportion. This may be accomplished by reducing load speed, load weight, or diameter or length of rotating parts.

Total driven inertia $(WR^2)_T$ is the sum of motor-rotor inertia and inertia of various rotating load elements referred to motor shaft speed, or

$$(WR^2)_T = (WR^2)_M + (WR^2)_L\left(\frac{RPM_L}{RPM_M}\right)^2$$

where $(WR^2)_M$ is motor inertia, $(WR^2)_L$ is load inertia, RPM_L is load speed, and RPM_M is motor shaft speed.

Relationship between load inertia, load speed, and equivalent load inertia referred to motor speed of 1800 rpm is shown in Fig. 4. In reducing total inertia, reduction in load speed can be as effective as reduction in load inertia. For example, load inertia of 6 lb-ft² at 3600 rpm and motor inertia of 6 lb-ft² are equal to $6+6\ (3600/1800)^2$, or 30 lb-ft² at motor shaft speed. If load speed is reduced 25 per cent to 2700 rpm, total inertia is reduced to 19.5 lb-ft². If load speed must be maintained at 3600 rpm, load inertia must be reduced by 44 per cent to 3.37 lb-ft² to obtain same total inertia of 19.5 lb-ft².

Selecting High-Slip Motors

Heat produced in duty cycles with frequent or long periods of acceleration can be reduced by proper selection of motor Design type. A motor with higher slip and lower full-load speed, such as NEMA Design D types, can be started more frequently than Design B with same temperature rise. This is indicated in Fig. 5 which shows temperature rise per number of starts per min for Design B and D, 1 to 25 hp, 1800-rpm motors of existing NEMA frames. Temperature-rise figures shown here are for an inertia load only; running load is not considered in this graph.

The important electrical difference in high-slip motors designed specifically for frequent starting or reversing service, such as NEMA Design D, is increased rotor resistance. This causes the following significant changes: (1) maximum torque is developed at lower rpm, (2) starting current is reduced, (3) starting power factor is increased, (4) full-load slip is increased, which means that full-load speed is reduced, and (5) full-load efficiency is reduced. As a result of these changes, the higher slip motor: (1) accelerates more rapidly in lower speed range, (2) develops smaller stator losses and less heat during acceleration, and (3) improves motor ventilation during acceleration because motor is running at higher average speed greater portion of the time.

Because of these factors selection of a high-slip Design

Table III — Comparison of Alternate Solutions for Duty Cycle Drive Problem

Basic motor specified is 5-hp, frame 254, continuous duty, 1800 rpm. Duty cycle is repeated once per hour. Total inertia is 4 lb-ft², direct-connected; 5-hp load.

Motor and Load Characteristics	All Motors Operate at Full Load for Duty Cycle Described			
	Continuous duty	Plug reversals		700 reversals using mech. brake stop
		500	700	
Average accelerating torque, ft lb	30	37	40	37
Average reversing torque, ft lb	27	42	45	42
NEMA Design type	B	D	D with special stator	D
Class of insulation	A	A	B	A
Temperature rise, C	40	50	75	50

presents four ways to reduce motor operating temperatures. For example, assume a NEMA Design B, 5-hp 1800-rpm motor in a 254 size frame is required to operate a full load between reversals, and to plug-reverse 10 times per min. Total inertia is 2.5 lb-ft². Assuming it is impractical to revise load speed or inertia, or allow temperature rise higher than 40 C, a NEMA Design D motor which can handle 15 plug stops without exceeding 40 C rise can be applied. Another solution would be to use an auxiliary brake, as previously described, but this may not be desirable because of increased machine complexity and added components which can be a source of equipment failure.

The graph in Fig. 5, which compares number of starts for NEMA Design B and D motors for a given temperature rise, is based on a maximum of 25 hp since motors of higher hp rating are seldom applied for frequent starting applications; their larger rotor inertias have a higher ratio of heat-produced to heat-dissipating-area. Where applications involve motors over 25 hp and require 5 or more starts per minute, special ventilation should be considered.

Summary of the various methods of reducing heat developed in a motor during frequent starts or reversals is given in Table IV.

NEMA Design D motors are available with various full-load slip characteristics which can be matched to load requirements. Standard NEMA full-load slips range from 5 to 8 and from 8 to 13 per cent. However, nonstandard values of higher slip may be used for severe starting or reversing requirements.

Determination of optimum slip value for a given application requires complex motor design calculations which must be performed by motor designer. To determine best Design type for greatest number of starts or reversals with minimum frame size for specified temperature rise, information listed in Table V should be supplied motor designer.

Table IV —
Methods of Reducing Heat Developed in Motor During Frequent Starts or Reversals

	Revise Duty Cycle	Revise Load Characteristics	Change Motor
Starts	a. Replace plug stops with brake stops b. Add clutch between motor and load, brake load only c. Replace plug stops with dynamic braking	a. Reduce max required load speed b. Reduce load inertia by using fewer, lighter, or smaller diam. rotating parts c. Reduce friction load	Select motor with: a. Higher rotor resistance or higher slip, or b. Lower rotor inertia at same hp, or c. Lower rated speed
Reversals	a. Replace plug reversals with brake stop, plus automatic reacceleration by special control b. Replace plug reversals with dynamic brake stops plus automatic reacceleration as above		

Frequently the load is difficult to describe because under different operating conditions the duty cycle varies considerably. The repeating cycle which has the highest running loads, the most frequent starts or reversals, and the shortest time at rest, produces the highest amount of heat and should be used in supplying data for this Table.

Ventilating Motors

REDUCING HEAT generated in the motor provides one basic means of keeping motor temperature within safe limits. Another basic solution is removal of heat from motor at a rate sufficient to maintain operating temperaures below injurious levels. This can be accomplished by proper application of the ventilation system of motor or by auxiliary fans or blowers.

Systems of ventilation used with the several standard enclosure types transfer heat from motor core and winding into surrounding air. Cooling methods used in the three basic types of enclosures vary somewhat in the means of using ventilating air for this purpose.

Heat transfer from motor to air is affected by many factors, including: (1) watts to be dissipated per unit of cooling area, (2) volume of cooling air available, (3) temperature differential between cooling air and hot surface, (4) efficiency of cooling air movement over dissipating area, and (5) effect of motor mounting surface or motor shaft temperature on motor temperature. Improving effectiveness of inbuilt ventilation systems of both open and enclosed motors can produce significant reductions in motor operating temperatures. Reduction of cooling by machine designs which restrict or block the entrance of external ventilating air into or around the motor enclosure may require a compensating increase in frame size and/or temperature rise to maintain specified motor rating and efficiency.

Special water-cooled, or submerged motors which use the liquid in which they are immersed as the cooling media, have limited application.

Improving Open-Motor Ventilation

Open or drip-proof motors use integral fans on shaft or rotor to draw air inside motor frame and into direct contact with motor windings and core. This ventilating system transfers heat at highest rate per sq in. of heat dissipating surface of the three motor-enclosure types. This high heat transfer is caused partially by higher temperatures of surfaces in contact with air and partially by the nature of these surfaces. For this reason, open or open drip-proof motors have lowest temperature-rise rating, in standard construction, of the three enclosures. Also, this type motor has highest continuous overload capacity or service factor; and frame size and weight is as small or smaller than any other of other enclosure types.

In a motor running in an open, well ventilated space, much rotor heat is transferred directly to surrounding air and does not contribute to winding temperature rise. If an open motor is used in frequent starting or reversing service, normal self-ventilation can be used to advantage by in-

Table V —
Data Required by Motor Designer to Determine Motor Design for Frequent Starting or Reversing Applications

Duty Cycle Description

1. Number of starts, reversals and stops per min in cycle
2. Duration of cycle
3. Time machine operates at full load
4. Time machine operates at no load
5. Time machine spends at rest
6. Rate of cycle repetition

Speed and Inertia of Rotating and Reciprocating Parts

Friction and Work Loads

Method of Control Required for Stopping or Reversing Mechanical Brake, Plug Reverse, or Other Combinations

Motor Description

1. Speed, rpm
2. Supply voltage and frequency
3. Enclosure and mounting
4. Temperature rise, if specified
5. Governing specifications such as JIC, NEMA, etc.

creasing length of time motor runs at full speed and reducing time at rest.

NEMA recommended frame sizes for open 40 C rise motors are smaller than enclosed fan-cooled 55 C rise motor for 50 hp 1800-rpm ratings or larger, in both 1956 standards and in recommended frame sizes for future designs.

Ventilating Open Motors in Restricted Spaces

If an open motor is mounted in a restricted space, entire heat output of the motor is available to raise stator temperature. In some instances such restriction doubles proportion of motor heat producing stator temperature rise.

In restricted spaces, a sufficient volume of air must be supplied to ventilate the motor. This volume may be obtained from Fig. 6, which shows the cu ft/min of 20 C air required to ventilate 40 C rise open motors up to 60 hp. The left-hand boundary of the shaded area, shown in color, corresponds to a theoretical maximum 100 per cent transfer of motor heat to air; in this case air enters the enclosure at 20 C and leaves at a motor temperature of 60 C. The right-hand boundary of the shaded area is a volume limit defined by minimum value of heat transfer, producing a 20 C temperature differential between motor exhaust air and motor winding. Practical application values lie between the boundaries shown.

Data in Fig. 6 are based on the assumption that air moves freely around the motor, driven either by the inbuilt fan or by an external fan or blower. It is also assumed that machine or equipment surfaces surrounding the motor are well insulated so as to neither add nor subtract heat to or from the area. In practice, this situation is seldom encountered. Where surrounding areas are cooler, removal of heat is aided; where they are hotter, they add to the cooling problem and increase required volume of air flow.

In providing for passage of cooling air through a restricted space and motor enclosure, air flow should be directed to prevent hot exhaust air from the motor from reentering motor cooling system.

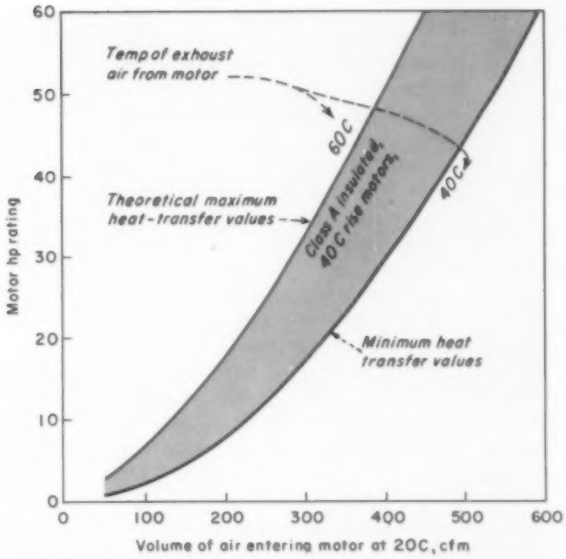


Fig. 6—Left-hand boundary of shaded area is theoretical max heat transfer in which 20 C air absorbs 100 per cent heat and is exhausted from motor ventilating system at 60 C. Right-hand boundary is minimum heat-transfer value at which 20 C cooling air absorbs sufficient heat to be exhausted at 40 C. Practical value for any application lies between these limits. It is also assumed no additional motor heat is introduced by walls of enclosure and that air flow is directed entirely on motor. Where flow cannot be concentrated in this manner, increased air requirements must be considered.

Ventilating Enclosed Motors in Restricted Space

Difficult problems of heat dissipation can arise in attempting to reduce motor temperature rise or frame size of enclosed motors. Such motors are normally rated 55 C rise, and at full load are operating close to maximum recommended temperatures for class A insulation in a 40 C ambient. Because of this, standard totally enclosed non-ventilated (TENV) and totally enclosed fan-cooled (TEFC) motors have a service factor of 1.00.

Totally enclosed non-ventilated motors circulate air within the enclosure using fans on rotor or shaft to transfer heat from motor windings and core to enclosing case. Heat is then radiated and conducted to external ventilating air which normally circulates over outside of the motor enclosure by natural convection or incidental drafts.

Totally enclosed fan-cooled motors also use internal fans. However, movement of ventilating air over outside of the motor is substantially increased by addition of external fans mounted on one or both ends of motor.

Safe motor temperatures in restricted locations may be maintained by utilizing the air flow of the motor fan or of supplementary fans or blowers. The volume of cooling air required to properly ventilated totally enclosed motors up to 60-hp ratings is shown in Fig. 7. Shaded area at left applies to 75 C rise motors with class B insulation, while area at right applies to 55 C rise motors with class A insulation. Significance of area boundaries and assumptions

made for Fig. 6 also apply here.

Two examples of enclosed-motor cooling in restricted locations are shown in Fig. 8. One example utilizes air flow of the motor fan as shown in (A). Here, the fan of a totally enclosed fan-cooled motor draws air into a machine column in which the motor is located. Air enters through lower side-column openings; hot exhaust air from the motor is blown and rises to leave through the upper openings in the door.

Supplementary fans or blowers can be used to reduce excessive motor temperatures or to reduce temperatures which may exceed other specified limits. In Fig. 8(B) an auxiliary four-blade fan is mounted on a drive sheave; it draws air through the lower opening in the door and over the motor located in the machine base.

Larger frame size is sometimes employed to improve motor cooling for totally enclosed non-ventilated motors 1800-rpm over 7½ hp. However, increased frame size increases rotor inertia, and is not recommended for frequent reversing service. More generally employed is the fan-cooled motor which can be built in smaller sizes in these ratings.

Because of heat-dissipation requirements, NEMA specifies larger frame sizes for non-ventilated 55 C rise motors than for the same enclosed fan-cooled motor in ratings over 3 hp under present standards, and over 1½ hp in recommended future designs.

The addition of separate ventilating fans attached to the motor, or separately mounted with ducts to the motor, is an effective means of improving enclosed motor ventilation. Air requirements from Fig. 7 apply. For motors up to 100 hp, flow of ambient air over motor enclosure is normally obtained by using a fan-cooled motor or auxiliary fans. Larger motors frequently utilize a mechanical heat exchanger or cooling air from an external source.

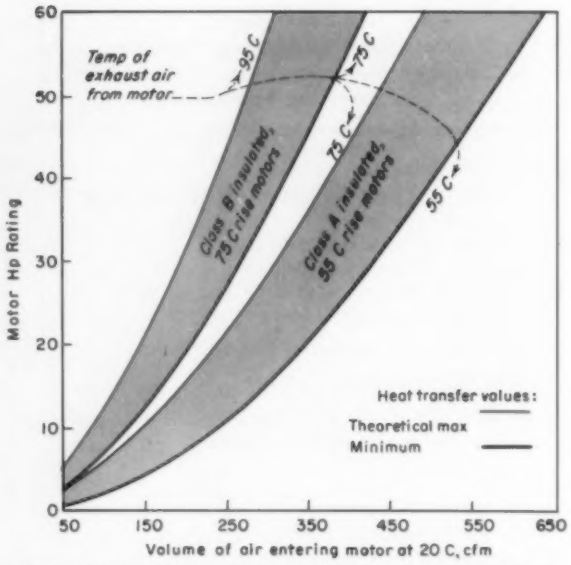


Fig. 7—Cooling air required to ventilate 1 to 60 hp totally enclosed motors. Method of using curves and qualifications for Fig. 6 also apply here.

Fan or Blower Drives

Special case of inherent auxiliary ventilation occurs in application of drive motors to fans or blowers handling ambient air of normal temperatures. Flow of fan-driven air over the motor may be utilized to dissipate motor heat to such an extent that frame size and hp rating may be reduced without exceeding standard temperature rise. Air motion is frequently not directed efficiently over the motor surface in such applications, but large volume of air movement compensates for this lack. For example, an 1800 rpm motor normally rated 25 hp is successfully employed in driving the 40 hp blower shown in Fig. 9, without exceeding normal temperature rise. The motor shown here is of flange-mounted construction.

Reducing External Heat

Where ambient air is excessively hot, or where abrasive or metallic particles in air make it unsuitable for cooling, motors can be ventilated using pipes or ducts, as shown in

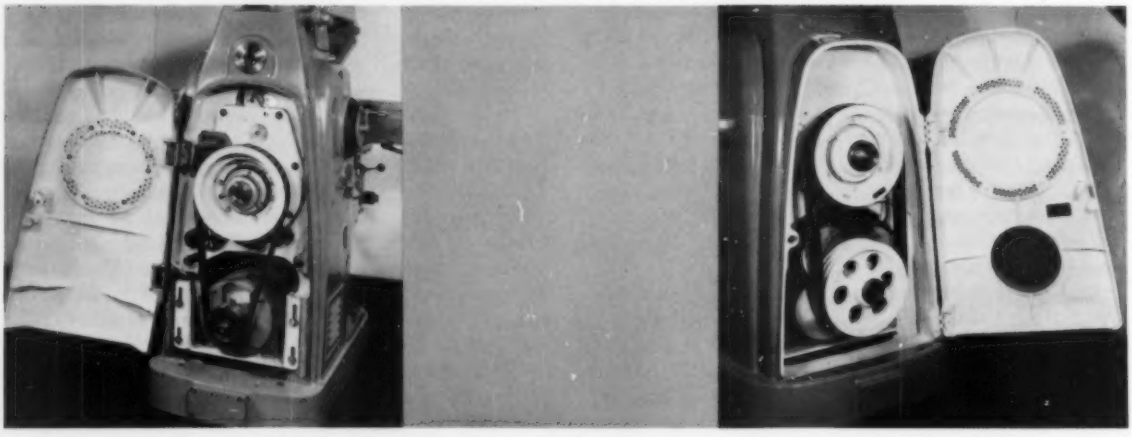


Fig. 8—Two examples of ventilating totally-enclosed drive motor in restricted spaces. (A) Spindle drive motor of machine by Cincinnati Milling Machine is located in base of column; ventilating air enters through lower side column openings, is blown across fan-cooled motor by motor fan and rises to leave through upper openings in the door. (B) Auxiliary-fan ventilation of enclosed motor in restricted space on milling machine by Cincinnati Milling. Four-blade propeller fan on drive sheave draws air in through lower opening in door and blows it over motor.

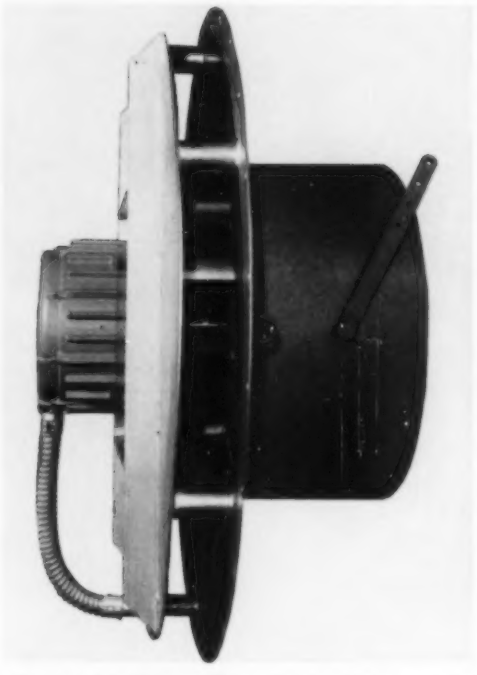


Fig. 9—Air-stream ventilated motor driving a centrifugal blower by Green Fuel Economizer Co. Large volume of air flowing over motor permits the 40-hp blower to be driven by an 1800-rpm airstream motor normally rated 25 hp without exceeding rated temperature rise.

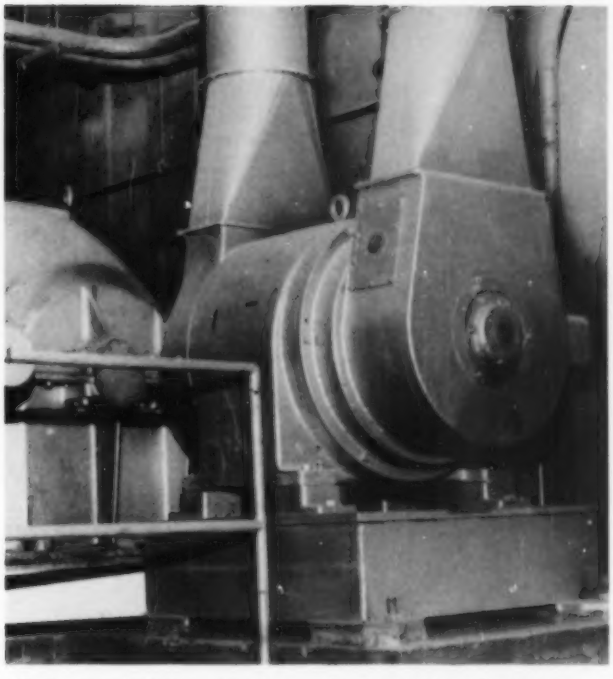


Fig. 10—In excessively hot, corrosive, or abrasive ambient air, motors can be ventilated by cool, clean air from ducts or pipes. Where motor is self-ventilated, ducts up to 20 ft can be used; beyond 20 ft auxiliary fans or blowers are required. Example by Farrell-Birmingham Co. is a 250-hp, 900-rpm totally enclosed motor driving a Banbury mixer through a gear reducer.

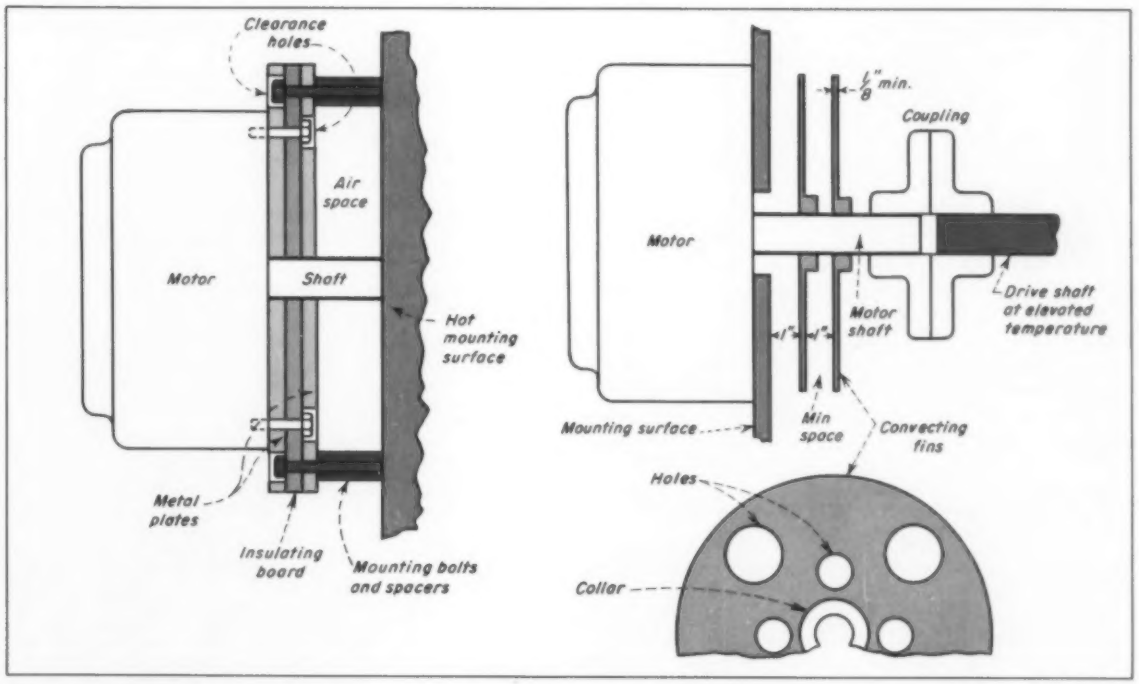


Fig. 11—(A) When motor must be mounted on a hot surface, construction shown here can be used to reduce heat transfer to motor. Size of motor which can use this type of mounting is limited only by strength of insulating board. (B) Where motor shaft must be connected to a drive shaft at elevated temperature, temperature of motor shaft may be reduced to safe limits by using convecting fins shown. Number and size of fins used depends on temperature of drive shaft.

Fig. 10. For self-ventilation, ducts up to 20 feet long are used; beyond this length auxiliary fans or blowers are used.

When motor, motor shaft, or both must be mounted in or on an area at elevated temperature, motor must be protected from the external heat by special means. If heat is transferred principally through motor mounting, it can be insulated as shown in Fig. 11(A). Dimensions can be modified to provide required temperature difference between heated surface and motor mounting. An increase of several inches in insulation-board thickness and a reduction of air space to ¼ in. will give maximum protection afforded by this design. Size of motor which can be mounted in this fashion is limited by mechanical strength of insulating board used.

Where external heat flows to motor through the shaft, use of "heat slingers" or convecting fins, constructed and attached as shown in Fig. 11(B), provides protection by setting up a circulation of air which removes heat from the fins. As temperature increases, additional convecting fins may be added, maintaining the spacing shown. Size and location of holes in the fins should be proportional to diameter of the motor and its flanges, as shown. Enough material must be left in the fin to provide adequate mechanical strength.

Where tests of motors using either of above methods show that conduction of heat is increasing motor temperature above that recommended for the motor insulation, both methods should be applied.

Overloading Motors

APPLICATIONS OCCUR in which limiting factors of available space or other specifications require that a chosen motor be operated beyond its normal 100 per-cent hp rating and temperature rise. For example, a 10-hp 1800-rpm motor carrying a continuous load at 40 C rise in a 30 C ambient was found to be overloaded 25 per cent by a proposed change in the drive. To maintain normal life expectancy, class B insulation could be used on the motor, provided increase in motor temperature rise above 40 C was acceptable. Test of the motor under 125 per cent load determined that motor temperature did not rise above allowable maximum for class B insulation.

Factors limiting motor overloading are: (1) motor operating temperature, (2) rpm at maximum load, (3) continuous and intermittent torque requirements at maximum load, and (4) overload protection. Motor speed is, within reasonable limits, reduced in proportion to load increase. An 1800 rpm motor rated at 4 per cent slip will have full-load speed of 1728 rpm. If load is increased to 125 per cent, slip will increase a minimum of 25 per cent and motor speed will drop to 1710 rpm.

In a constant torque load this speed change may not be significant; it is, however, in applications where power required is proportional to the cube of motor speed, such as in a centrifugal pump. Also, increase in motor temperature raises rotor resistance and further reduces motor speed. For these reasons, tests under operating conditions are recommended for speed-sensitive drives.

Maximum torque which a motor can develop is a factor which must be considered even though an anticipated overload is of short duration. NEMA Design B motors should not be continuously loaded over 140 per cent, even though adequate protection for the windings is provided by use of special insulation. Maximum torque value beyond which a motor becomes unstable can be determined from the motor speed-torque curve provided by the manufacturer. Overloads of short duration should not exceed 80 per cent of this maximum.

Pulsating loads such as in a punch press are a special problem for which detailed application data was presented in an earlier article in PRODUCT ENGINEERING, "Motors for High Inertia Drives" April 1956 page 142.

Electrical protection for motors carrying a continuous overload can be provided with special overload heater coils, or special control relays. If overloads in excess of 15 per cent are anticipated, the control manufacturer should be consulted.

Other Limitations on Overload

Unusual applications occur in which neither temperature rise nor ambient temperature are limiting factors in determining maximum overload which may be safely carried. For example, a standard motor located in the air stream of a blower may operate far below its temperature rise, even though overloaded. In these cases other factors which determine maximum safe load must be evaluated, such as: shaft strength; bearing capacity; starting and maximum torque compared to load requirements; and effect of lower operating speed on load. In addition, starter rating and size of heater coils must be examined if the overload is to be carried continuously.

ADDITIONAL READING. Other articles evaluating factors involved in selection and application of motors for machine-tool drives have appeared in earlier issues of PRODUCT ENGINEERING. A new method for selecting best combination of flywheel inertia and motor for cyclic power requirements of a constant-running machine such as a punch press, is presented in "Driving High Inertia Loads" April 1956 page 142, by the same author.

A comparison between conventional NEMA motors and axial-air-gap high-inertia motors is made in "Axial-Air-Gap Motors for Machine Tool Drives" September 1955 page 129. Method of calculating flywheel effect of motor rotors is also included.

A detailed analysis of NEMA Design B, C, and D torque and speed ratings appears in "The Importance of Duty Cycle in Selecting Polyphase Induction Motors" November 1954 page 174. In addition, calculation of various duty-cycle elements to satisfy drive requirements is described.

Starting and torque characteristics for a number of different types of machine-tool loads is discussed in "Synchronous Motor Drives" in the Annual Handbook Issue for 1956 on page H-23.

In the Annual Handbook for 1954 on page H-24, starting characteristics of principal types of squirrel cage motors are given in "Significance of WK^2 and How to Calculate It. This article derives moments of inertia for various shaped parts and includes approximations for calculating WK^2 for flywheels, spur or helical gears, and motor rotors.

"How Big a Motor?" September 1952 page 142, reviews four methods for determining proper motor rating for duty-cycle operation: calculating from motor data, using load-torque tests, making metered running tests, and taking temperature-rise on a heat run.

Clock-Escapement Mechanisms

Analysis of balance-wheel and run-away clock escapements; formulas, curves and typical applications including time devices, torque regulators, accelerometers, velocity indicators.

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PRINCIPLES USED IN CLOCK ESCAPEMENT MECHANISMS offer many opportunities in the design of commercial and military devices. But because of the miniature size of clocks and watches, and the lack of formal treatment of the kinematic and dynamic properties of these mechanisms, they have often been overlooked in the design of other products. These escapement mechanisms fall into two categories: balance-wheel escapements, such as shown in Fig. 1, and run-away escapements which are similar to balance-wheel escapements but without the governing properties of the balance-wheel assembly.

Both types can serve as timers; the balance-wheel escapement as a precise timing device with an accuracy well within ±1 per cent, and the run-away escapement as an approximate timer with an accuracy about ±7 per cent. Typical applications of timers are in electric circuitry and military fuses.

In addition, these mechanisms function as govornors to control linear or angular displacement, torque, and velocity in devices such as cams, clutches, brakes, gears, relays, firing mechanisms.

The run-away escapement is used as the basic mechanism in two important instruments: accelerometers and velocity indicators. Accelerometers are very useful for evaluating sustained shock and vibration in machine tools and equipment. Accelerometers using the escapement principle are rugged and cheap, although their accuracy is limited to that of the run-away escapement. As a velocity indicating device, the run-away escapement can be incorporated in aircraft and missiles to translate accelerating force into resulting velocity. In addition it can serve as an impulse metering device for shock loading.

Balance-Wheel Escapement

Timing regulation of a clock is based on the actions of the balance-wheel escapement whose principal elements are shown in Fig. 1. Pivot points of the scape wheel, lever and balance wheel are usually in a straight line. The balance wheel and hairspring constitute a vibrating or swinging pendulum system with a fixed period. The scape wheel has an intermittent clockwise rotation which counts the number of times the balance wheel oscillates and also supplies to the balance wheel the energy it loses in friction and windage.

For every complete oscillation (back and forth) of the balance wheel, the lever permits the scape wheel to advance one tooth. In the course of permitting the scape wheel to advance, the lever in turn transmits some energy to the balance wheel from the scape wheel.

The mainspring (not shown in Fig. 1) drives the scape wheel through a gear train. Pallet stones are made of ceramic material or jewel. Although the balance wheel receives an impulse from the lever via the balance wheel jewel, the jewel swings much farther than the lever can follow so the two are in contact for only a portion of the total jewel arc of motion. The contact angle is called the balance arc.

Sequence of events is shown in Fig.

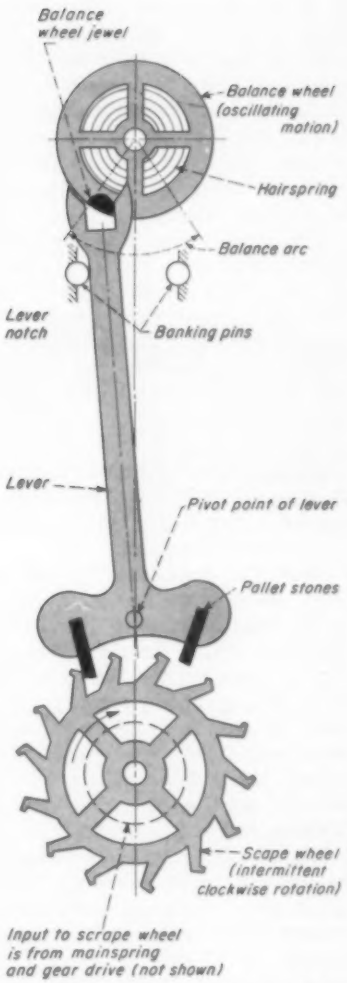


Fig. 1—Principal elements of a balance-wheel escapement mechanism. Balance wheel and lever constitute a vibrating system with a fixed period which governs the clockwise rotation of the scape wheel.

2: As the jewel starts its downward travel (Fig. 2A), the banking pin holds the lever in just the right position for the jewel to miss one corner of the lever notch and engage the other. The lever at this time is restrained against the banking pin by clockwise tension of the mainspring on the scape wheel.

The jewel strikes the lever and drives it clockwise (Fig. 2B), which in turn causes the left pallet *L* to slip past the scape wheel tooth. The scape wheel, now begins to move clockwise and the top of its tooth gives an impulse to the bottom of the left pallet as it passes by (Fig. 2C). This gives a clockwise impulse to the lever which drives the jewel (instead of being driven by it). This impulse supplies energy to the balance wheel to maintain it in motion.

After the scape wheel travels a short distance another tooth locks on the right pallet stone (Fig. 2D). The lever strikes the right banking pin and stops but the balance wheel keeps turning until its energy is overcome by tension in the hairspring, pivot friction and air resistance. The balance wheel has approximately a 360 deg rotation in each direction as shown in Fig. 2(E).

Pressure of the scape wheel tooth on the right pallet keeps the lever locked against the right banking pin because the line of action passes through or above the lever pivot point, as shown in Fig. 2(F).

Entire sequence of movements is repeated when the balance wheel and jewel return to the lever under the influence of the hairspring.

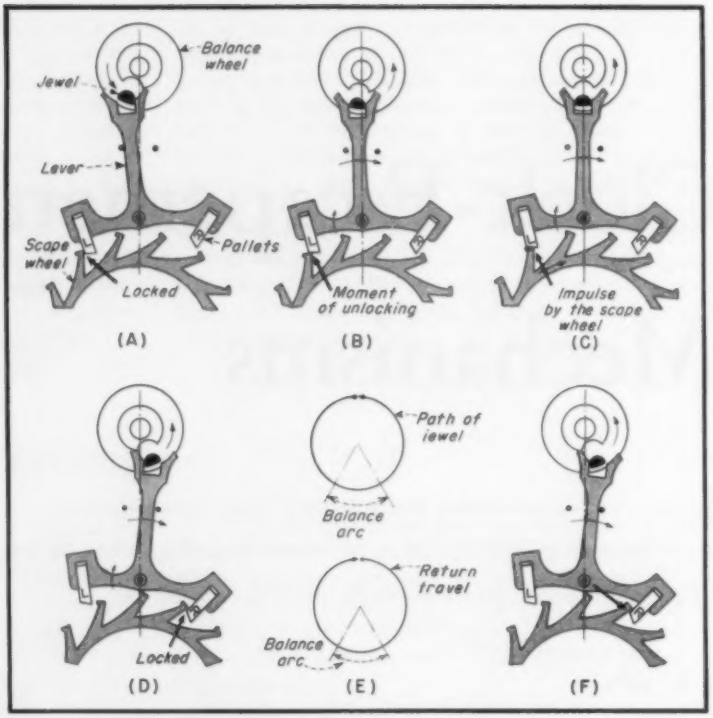


Fig. 2—Sequence of events in a clock movement.

Run-Away Escapement

If the balance wheel assembly in Fig. 1 was removed, the remaining elements would constitute a typical run-away escapement mechanism. The name characterizes the action of this mechanism in that the torque derived from the energy stored in the mainspring will dissipate itself as fast as the inertia restraints of the system will permit. The motion of the scape wheel is no longer controlled by the balance wheel system and consequently it will "run-away."

This mechanism can be used as a simple, rugged and relatively inexpensive device for metering relatively short periods of time with an accuracy about 10 to 15 per cent. Fig. 3 illustrates a typical run-away escapement system. Torque transmitted through the gear train rotates the scape wheel which, in turn, oscillates the pallet. The starting and stopping of the pallet as it oscillates acts as an inertia brake or governor on the rest of the system.

In this example, the escapement controls the action of a cam-follower mechanism. The principle can be adapted to many other applications such as: Fig. 4—crude timer (5 min.) for closing an electric circuit; Fig. 5—velocity indicating device used in computers for integrating acceleration-time functions.

An accurate expression defining the motion of a run-away escapement is quite complex, but it is possible to obtain close accuracies with the following assumptions:

(1) Inertia of the driving system on the pallet is negligible.

(2) Friction on the teeth of the pallet, scape wheel and pivots is negligible.

(3) Torque driving the pallet remains constant for each half-cycle of the pallet.

(4) Impact between the scape wheel and pallet teeth is inelastic thus preserving the periodicity of the pallet motion.

(5) Pallet comes to rest twice in each cycle.

Subscripts w and p indicate properties of the scape wheel and pallet respectively. Similarly, subscripts 1 and 2 indicate actions for the first half and second half of the pallet cycles respectively. Symbols used in the analysis are defined in Table I.

Equation defining the motion of the pallet is simply

$$T_p = I_p \frac{d^2\theta}{dt^2} \qquad (1)$$

The initial conditions at $t = 0$ are $\theta = 0$ and $d\theta/dt = 0$. Integrating Eq (1) twice and applying the initial conditions results in

$$t_1 = \sqrt{\frac{2I_{p1}\theta_1}{T_{p1}}} \qquad (2)$$

Where θ_1 and t_1 denote the half-cycle amplitude and half-cycle period respectively, and the total pallet amplitude is $\theta_1 + \theta_2 = 2\pi/n$.

Action for the second half-cycle motion of the pallet is derived in a similar manner. For the case where motions of the first and second half-cycles are symmetrical, the frequency

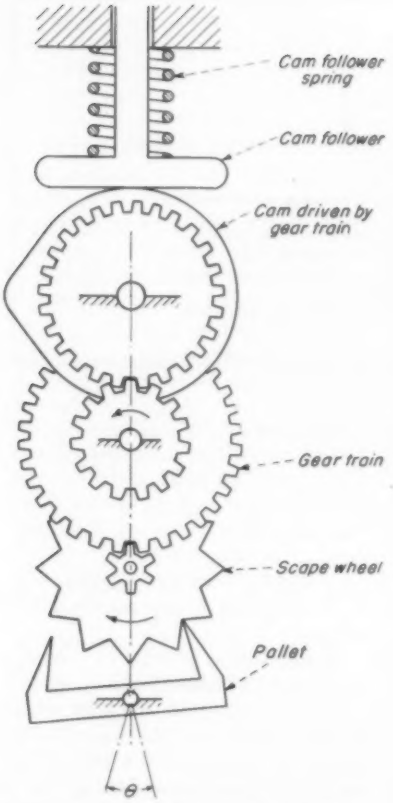


Fig. 3—Run-away escapement system for governing the speed of a cam system driven by a mainspring.

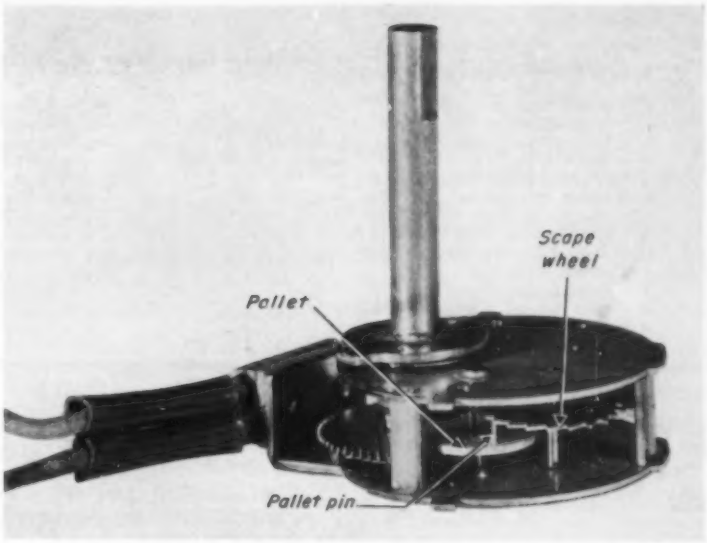
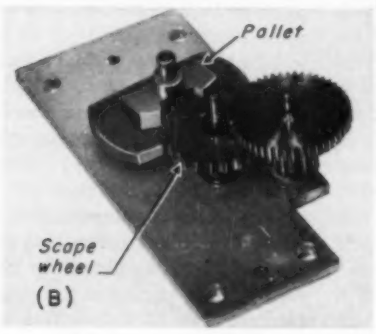


Fig. 4—Timer for closing an electric circuit based on the mechanism in Fig. 3.



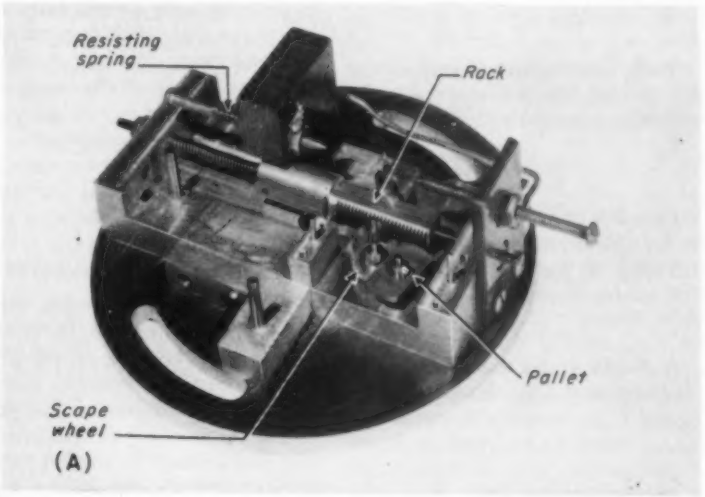


Fig. 5 (A)—Velocity indicating device. If the device is mounted on an object traveling to the right under an acceleration force, the rack will shift to the left. Resistance of the escapement system and spring governs the motion of the rack so that its position indicates the velocity of the object at any time. (B) Underside of escapement mechanism.

is equal to 1/2 t_1, or

$$= \frac{1}{2}\sqrt{\frac{T_{p1}}{2I_{p1}\theta_1}} \qquad (3)$$

It is usually more convenient to express Eq (3) in terms of the geometric parameters and inertia of the scape wheel. Based on the initial assumptions, a torque acting on the scape wheel will cause the mechanism to speed from a rest condition and then be stopped suddenly by impact with the pallet. All the kinetic energy of the scape wheel is assumed to be consumed during this impact. The consumed energy for one pallet cycle is

$$T_w(\theta_1 + \theta_2) = T_w\frac{2\pi}{n} \qquad (4)$$

The assumption leading to Eq (6) can be justified considering the very small amount of free-travel of the scape wheel between intervals of contact with the pallet. A well designed escapement can limit this free travel to about one-tenth the pitch of the wheel teeth.

For each part of the cycle, the work done by the pallet wheel torque can be equated to the kinetic energy of the scape wheel and pallet so that

$$T_w\theta_1 = \tfrac{1}{2}I_{w1}\omega_{w1}^2 + \tfrac{1}{2}I_{p1}\omega_{p1}^2 \qquad (5)$$

A similar expression is obtained for the second half of the cycle. Since the scape wheel is to be used as the reference, the equivalent moment of

Table I—Definition of Symbols

a = acceleration in g's (in./sec²/g)
f = frequency of pallet, rad/sec
f_b = frequency of balance wheel, rad/sec
g = acceleration ot gravity, 386 in./sec²
I = moment of inertia, in.-lb-sec²
k = spring rate, lb/in.
n = number of scape wheel teeth
P_0 = initial spring force at $x = 0$, lb
Q = torsional spring constant of hairspring in balance wheel, in.-lb/rad
r = pitch radius of gear, in.
R = gear reduction from scape wheel to mainspring
s = distance, in.
t = time, sec
T = torque, in.-lb
T_m = maximum torque at the hairspring, in.-lb
v = velocity, in./sec
x = displacement of a rack, in.
α = top face angle of scape wheel teeth, rad
β = rotation of mainspring, rad
ϵ = efficiency between mating gears
γ = rotation of scape wheel, rad
η = efficiency of energy transmission from mainspring to hairspring
θ = angular displacement of pallet, rad
ϕ = rotation of balance wheel, rad

inertia referred to the scape wheel is

$$\tfrac{1}{2}I_w\omega_w^2+\tfrac{1}{2}I_p\omega_p^2=\tfrac{1}{2}\omega_w^2\left[I_w+I_p\left(\frac{\omega_p}{\omega_w}\right)^2\right] \quad (6)$$

Equivalent moment of inertia I_e referred to the scape wheel is:

$$I_e = I_w + I_p\left(\frac{\omega_p}{\omega_w}\right)^2 \quad (7)$$

From the original assumptions it follows that the following ratios are approximately equal:

$$\frac{\omega_p}{\omega_w} = \frac{T_w}{T_p} \quad (8)$$

For most cases, the ratios expressed by Eq (8) are not the same for each half-cycle of the pallet and must be evaluated separately.

$$T_w\theta_1 = \tfrac{1}{2}I_{e1}\omega_{w1}^2 \quad (9)$$

A similar expression is obtained for the second half, although inertias I_{e1} and I_{e2} are not usually equal since ω_p/ω_w varies during each half-cycle of the pallet.

Angular velocity of the scape wheel is

$$\omega_{w1} = \left(\frac{d\theta}{dt}\right)_1 = \sqrt{\frac{2T_w\theta_1}{I_{e1}}} \quad (10)$$

Integrating Eq (10) and using the initial condition $\theta = 0$ when $t = 0$ results in

$$t_1 = \sqrt{\frac{2I_{e1}\theta_1}{T_w}} \quad (11)$$

A similar expression results for the second half of the pallet cycle so that

$$t_1 + t_2 = \frac{1}{f} = \sqrt{\frac{2I_{e1}\theta_1}{T_w}} + \sqrt{\frac{2I_{e2}\theta_2}{T_w}} \quad (12)$$

A geometric constant K can be introduced to simplify the expression to

$$f = \sqrt{T_w}/K \quad (13)$$

where

$$K = 1.73[(I_{e1}\theta_1)^{1/2} + (I_{e2}\theta_2)^{1/2}] \quad (14)$$

Based on Eqs (4) and (12) a mechanism can be devised to provide a cheap and rugged means for timing intervals of about 0.05 to 300 seconds. Limitation on the timing interval is governed only by the amount of energy capable of being stored in the main spring. Because of the relatively inefficiency of the mechanism, longer intervals than 300 sec would require massive power springs.

Use of the above equations is illustrated with a numerical problem in the latter part of the article.

Factors Affecting Accuracy

Timing mechanisms based on the run-away escapment are, by their nature, crude devices for metering fixed amounts of time. Principal reason is that no means have been provided for accurately governing the dissipation of the energy stored in the mainspring. If the run-away escapement had a means for better controlling the motion of the scape wheel, it then would represent an accurate device for metering time intervals. Such a device is the balance wheel escapement described in Fig. 2.

A well designed balance wheel escapement can meter time within a tolerance of ± 1 per cent. In a watch, the accuracy is considerably better; minimum absolute accuracy is ½ cycle of the balance wheel. Conventional clock balance wheel escapements have a frequency of 2.5 cycles per second with the 15 tooth scape wheel turning at about 10 rpm.

In many applications, these frequencies are too low. For example, consider the torque-governing system schematically illustrated in Fig. 6.

Input torque T_e may be a variable function. To obtain a constant output torque T_1 a balance-wheel escapement is coupled to the system to absorb the fluctuations of the input torque. In other words, $T_e = T_1 + T_2$ where T_2 varies approximately with T_e thus making T_1 approximately constant.

Problem here is that for conventional balance wheel frequencies, the order of magnitude of scape wheel torque T_2 is 0.0002 in.-lb, in all probability too small for this application. Any slight variation of driving torque in the mechanism drive for a constant torque input would result in a wide torque range for the clock governor to handle. Too great a torque impulse for a specific balance wheel will cause overbanking.

To obtain more equitable relationship between mechanism and governor torque, the balance wheel must operate at a higher frequency (for example 50 cycles per sec). This can be accomplished as follows:

One of the characteristics of a balance wheel escapement is that its timing is virtually unaffected by discrete variations in mainspring torque. As the torque of the mainspring is lowered, the frequency of the balance wheel and its effect on timing accuracy will decrease only slightly. But at exceedingly high mainspring torques, overbanking occurs and the escapement completely loses its isochronic properties. Overbanking occurs when the balance wheel swing is obstructed and is not allowed to attain its natural amplitude for a given scape wheel torque. At this condition, the balance jewel strikes the back of the lever thus jamming the motion.

These conditions generally limit

the mainspring torque variations in balance wheel escapements to about 3:1. However, if extreme care is exercised, driving torque ratios in excess of 6:1 can be designed at a slight sacrifice of timing accuracy.

In addition to the problem of overbanking, the sensitivity of escapements to lever alignment must be considered. A clock is said to be "in-beat" when in the neutral position of the hairspring, the balance jewel is centered in the lever fork. A typical tolerance for this alignment is within ± 4 deg of this center position. Once the tolerance limit is exceeded, self-starting of the clock is jeopardized. This necessitates extreme care in the setting and subsequent handling of the clock escapement. Therefore, in designing the scape wheel, avoid overbanking by minimizing the torques and inertias.

Scape Wheel Design

Fig. 7 illustrates a typical scape wheel designed. Magnitude of angle α influences both the starting torque and the maximum permissible torque and should be kept as small as possible for satisfactory operation. Also, the teeth locking surfaces should direct the normal forces N_1 and N_2 close to the center of rotation of the pallet.

As α is decreased, the energy transferred to the balance wheel by a specific scape wheel torque is reduced. This reduction in balance wheel energy is accompanied by a decrease in balance wheel amplitude, which reduces the possibility of overbanking. Also, the normal force of the pallet against the impulse face of the scape wheel is directed nearer the center of the scape wheel. In this manner, the restrictive torque caused by pallet reaction will be minimized at starting.

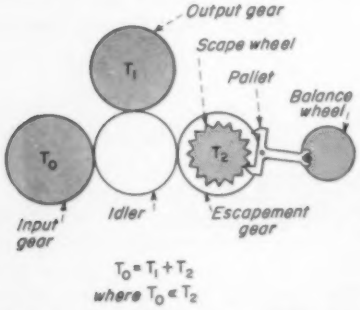


Fig. 6—Schematic of a balance-wheel escapement used as a torque regulator. The escapement absorbs the fluctuations in input torque T_0 to give a constant output torque T_1.

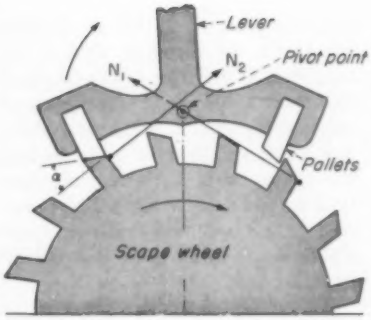


Fig. 9—Variation of factors affecting the accuracy of a velocity.

If N_1 passes above and N_2 passes below the center of pallet rotation, the resultant torque on the pallet will tend to draw it into the scape wheel. This condition will cause jamming under high scape wheel torques since the impulse of the balance wheel on its return stroke may not be great enough to withdraw the pallet.

For optimum condition where both N_1 and N_2 pass through the center, the scape wheel will neither drive nor jam the lever while the pallet pins are engaging the teeth locking surfaces. This design also provides for low running torques since the balance wheel will need less energy to disengage the pins from the locking surfaces. Fig. 7 shows N_1 passing through the pallet center of rotation and N_2 passing slightly above. This gives a slight driving torque, an advantage when tolerances accumulate.

In the actual design of balance wheel escapements, of the type shown in Fig. 1, space and weight limitations determine the moment of inertias of the elements, the radii, number of teeth, pitch, angle α, angle of action of scape wheel with the impulse face of the pallet, the angular rotation of the mainspring and other physical dimensions. Principal variables remaining are the balance wheel frequency, the gear reduction between the scape wheel and mainspring, and the torsional spring constant of the balance wheel hairspring.

Desired time interval for one cycle of the balance wheel jewel is determined by the equation

$$t = \frac{\beta n R}{2\pi f_b} \qquad (15)$$

For optimum functioning of the scape wheel over the range of mainspring torques, it is desirable to have maximum balance wheel amplitude, just short of overbanking. Thus, the balance wheel will still have a sufficiently large amplitude at lower mainspring torques.

Maximum energy imparted to the lever by the scape wheel must not exceed the energy absorbed by the balance hairspring. Therefore

$$\tfrac{1}{2}Q(\Delta\phi)^2 \geqq \eta \frac{T_m(\Delta\theta)}{R} \qquad (16)$$

Factor η represents the percentage of energy actually transmitted to the balance wheel taking into account friction, inertia, hairspring hysteresis and other energy losses. For the most part, η would have to be determined experimentally after a test model is built.

Thus far, Eqs (15) and (16) present three apparent unknowns: R, f_b and Q. The third necessary equation comes from the fact that the balance wheel vibration system is by its nature simple harmonic motion. Therefore,

$$f_b = \frac{1}{2\pi}\sqrt{\frac{Q}{I}} \qquad (17)$$

where I = balance wheel inertia (constant for a particular system).

Design procedure is to choose a convenient gear ratio R and consequently determine the balance wheel hairspring constant Q from Eq (18). Once Q is determined, the balance wheel and escapement frequency f_b can be found using Eq (17). Choice of R and f_b must be compatible with the required time delay as related by Eq (15).

Experimental Modifications

Small variations in pallet or scape wheel tooth shape can alter any predetermined calculations. Therefore, the analytical design should be verified experimentally. After a test model is built the relation between the actual values and desired values can be obtained by using the following equations where subscript e denotes the actual values measured in the test model:

$$\frac{f_b}{f_e} = \sqrt{\frac{Q}{Q_e}} \qquad (18)$$

$$\frac{Q}{Q_e} = \frac{T/R}{T_e/R_e} \qquad (19)$$

Maximum scape wheel torque T_e in

the test model is found by using a hairspring which drives the balance wheel just short of overbanking. Combining Eqs (15), (18) and (19), and solving for R results in:

$$R^3 = \left(\frac{2\pi l f_e}{\beta n}\right)^2 \left(\frac{TR_e}{T_e}\right) \qquad (20)$$

The test model can thus be adjusted to the desired time interval t by correcting the gear ratio

Escapement Used as an Accelerometer

Up to now, the application of escapements have been limited to purely timing functions. However, the nature of the escapement motion lends itself to its utilization as a second order integrating accelerometer.

Usual purpose of such an accelerometer is to sense and evaluate the distance a body has traversed under the influence of an accelerating field. History of motion of the body prior to this accelerating field must be evaluated by other means.

If the acceleration is constant, the change in distance of a body during a specific period of time is

$$\Delta s = \tfrac{1}{2} a g t^2 \qquad (21)$$

where the acceleration is in terms of number of g's. Solving for t gives:

$$t = \sqrt{\frac{2\Delta s}{ag}} \qquad (22)$$

From Eq (22) it can be seen that to be an accelerometer a mechanism must run for a period of time inversely proportional to the square root of the applied acceleration. The run-away escapement is just such a mechanism.

Fig. 8 (A) shows a rack coupled to a gear train which terminates in a run-away escapement. If the accelerating field is in the direction shown, the force due to the mass of the rack will be opposite and against the restraint imposed by the escapement system. A latch is included in order to lock the system until a discrete acceleration is sensed. For the sake of simplicity, it is assumed that this acceleration has a mean value that is constant.

Torque exerted on this scape wheel is directly proportional to acceleration. From Eq (13) it follows that f is proportional to $\sqrt{T_w}$ and that

$$f = K_1 \sqrt{T_w} = K_2 \sqrt{mga} \qquad (23)$$

Integrating Eq (23) and using the initial condition that $x = O$ when $t = O$ results in

$$t = \frac{x}{K_2 \sqrt{mga}} \qquad (24)$$

Eq (24) has the same form as Eq (22) which satisfies the requirements of a double integrating accelerometer. If Eqs (22) and (24) are equated, then s can be determined as a function of x (independent of a):

$$\Delta s = \frac{x^2}{2mK_2^2} \qquad (25)$$

Although the above example illustrated axial motion in a linear accelerating field, the basic mechanism can be applied equally well to rotational motion of an unbalanced rotor in any accelerating field.

Velocity-Indicating Device

With the addition of a resisting spring, the run-away escapement can be transformed from an accelerometer into an approximate velocity indicating device (first order integrating device) as illustrated in Fig. 8 (B). Here the influence of an acceleration field would cause the rack to move at a certain rate so that the position of the rack indicates the velocity at any particular time. For example, if the device is attached (with the rack free) to an object falling under the influence of one g, or traveling under a variable acceleration, position of the rack would indicate velocity. The velocity indicating device can be applied as integrator for rocket boosted vehicles as well as an impulse metering device for shock loading.

With the addition of the spring, the motion of the rack as expressed in Eq (23) must be modified to:

$$\frac{dx}{dt} = K_2 \sqrt{mga - P_0 - kx} \qquad (26)$$

where P_o is the initial spring force at $x = O$, and k the spring rate.

Since a is assumed to be constant, the variables are separable. Integrating Eq (26) and applying the initial conditions of $x = O$ when $t = O$ results in

$$x = K_2 t \sqrt{mga - P_0} - \frac{K_2^2 k t^2}{4} \qquad (27)$$

Velocity of the body under a constant acceleration is $v = a\,g\,t$. Using the value of t from this expression into Eq (27) results in a quadratic equation whose solution is:

$$v = \frac{2ag}{K_2 k} \sqrt{mga - P_0} \left[1 - \sqrt{1 - \frac{kx}{mga - P_0}}\right] \qquad (28)$$

Limitation on displacement is governed by the fact that the expression under the radical of Eq (26) cannot

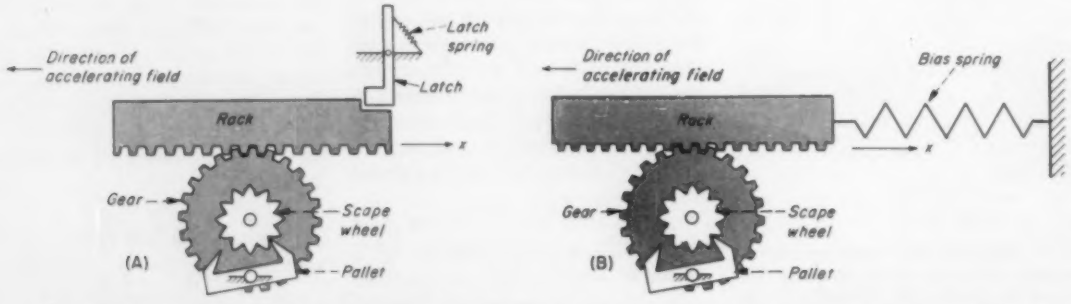


Fig. 8—Schematic of an accelerometer (A) and a velocity indicating device (B) using a run-away escapement system. A model of the velocity indicating device is shown in Fig. 5.

be negative, so that x_{max} is equal to

$$x_{max} = \frac{mga - P_0}{k} \quad (29)$$

Similarly, the limitation on the time interval is found by solving Eq (27) for t and using the value of x_{max} from Eq (29):

$$t_{max} = \frac{2\sqrt{mga - P_0}}{kK_2} \quad (30)$$

In order for Eq (37) to be more work-

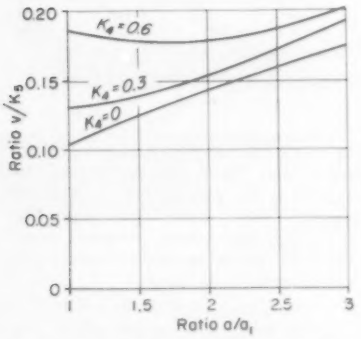


Fig. 7—Magnitude of angle α and direction of normal forces N_1 and N_2 influence the torque relationship between scape wheel and lever.

able the following transformations are made:

$$kx = K_3 mga_1 \quad (31)$$
$$P_0 = K_4 mga_1 \quad (32)$$

where K_3 and K_4 are equating ratios and a_1 the minimum acceleration that may occur. Inserting the values of P_0 and kx into Eq (28) and simplifying gives

$$v = \frac{2x}{K_2 K_3}\left(\frac{a_1 g}{m}\right)^{1/2}\left(\frac{a}{a_1}\right)\left(\frac{a}{a_1} - K_4\right)^{1/2}$$
$$\left[1 - \left(1 - \frac{K_3}{\frac{a}{a_1} - K_4}\right)^{1/2}\right] \quad (33)$$

For any specific mechanism, the values of x, K_2, m, a_1, K_3 and K_4 are constant so that v is a function of the acceleration a only. The sum $K_3 + K_4$ must be less than one, as can be noted from Eq (26). Actually, the sum is seldom higher than 0.8.

Fig. 9 shows the variation of v with a/a_1 based on Eq (40), when $K_3 = 0.2$ and $K_4 = 0, 0.3$ and 0.6. For this typical case, Eq (40) becomes

$$v = K_5\left(\frac{a}{a_1}\right)\left(\frac{a}{a_1} - K_4\right)^{1/2}$$
$$\left[1 - \left(1 - \frac{0.2}{\frac{a}{a_1} - K_4}\right)^{1/2}\right] \quad (34)$$

where

$$K_5 = \frac{10x}{K_2}\left(\frac{a_1 g}{m}\right)^{1/2} \quad (35)$$

Fig. 9 indicates that for minimum variation in velocity during a 3:1 acceleration change a spring with a constant of $K_4 = 0.6$ should be used. The variation in velocity will then be minus 4 per cent for the 2:1 acceleration range and plus 8 per cent for the 3:1 acceleration range. These variations can be reduced by trying better combinations of K_3 and K_4 over a desired acceleration range.

Sample Calculations

Known factors in the design of a typical velocity measuring escapement are: $x = 1.0$ in.; $mg = 0.10$ lb; $a_1 = 10$ g's; $P_0 = 0.6$ lb; $k = 0.2$ lb/in.; $(a/a_1)\max = 2$;
From Eq (31):

$$K_4 = \frac{0.6}{10(.1)} = 0.6$$

$$K_3 = \frac{(.2)(1)}{10(.1)} = 0.2$$

Referring to Fig. 8(B), let it be assumed that

I_1 = scape wheel inertia = 0.3×10^{-6} in-lb-sec²
I_2 = pallet inertia = 1.0×10^{-6} in-lb-sec²
I_3 = gear inertia = 0.25×10^{-6} in-lb-sec²
I_4 = rack inertia = 2.0×10^{-6} in-lb-sec²
e = mesh efficiency between each pair of gears = 0.9

Furthermore, let it be assumed that $\omega_4/\omega_2 = \omega_4/\omega_1 = \frac{1}{4}$, and that

$$\left(\frac{\omega_2}{\omega_1}\right)_a = 1.2 \text{ (first half of cycle)}$$

$$\left(\frac{\omega_2}{\omega_1}\right)_b = 1.0 \text{ (second half of cycle)}$$

From Eqs (7) and (12), it follows that

$$I_{ea} = \frac{I_1}{e} + \frac{I_2}{e^2}\left(\frac{\omega_2}{\omega_1}\right)_a^2 + \frac{I_3}{e} + I_4\left(\frac{\omega_4}{\omega_1}\right)^2$$

A similar expression for I_{eb} can also be obtained. Inserting the numerical values results in $I_{ea} = 2.516 \times 10^{-6}$, $I_{eb} = 2.070 \times 10^{-6}$.
Assume also that $\theta_a = 0.12$ rad and $\theta_b = 0.15$ rad, then $K = 1.565 \times 10^{-6}$ from Eq (14). Now

$$v = r\omega_2$$

where r = pitch radius of gear = 0.1 in. for this example; v = linear velocity of rack, and $\omega_2 = \omega_1$ = angular velocity of gear and scape wheel, rad/sec. From the natural motion of the escapement, ω_1 can be determined as a function of the pallet frequency, f, and the number of scape wheel teeth, n.

$$\omega_1 = \frac{2\pi f}{n} = \frac{v}{r}$$

Where n is obtained from a modification of Eq (4):

$$n = \frac{2\pi}{\theta_a + \theta_b} = \frac{2\pi}{0.27} = 23.3 = 24$$

Therefore, the pallet frequency is

$$f = \frac{nv}{2\pi r} = 38.3v$$

Constant K_2 can be determined as a function of K_1 by equating Eqs (13) and (18):

$$K_2 = \frac{\sqrt{r}}{38.3K_1} = 5.27$$

Constant K_5 now can be evaluated using Eq (42)

$$K_5 = \frac{(10)(1)}{(5.27)}\sqrt{\frac{(10)(32.2)^2}{0.1}} = 610$$

From the curve of Fig. 9 for $K_4 = 0.6$, the values of v/K_5 for a/a_1 of 1 and 2 are found to be 0.185 and 0.177 respectively. Therefore the deviation of velocity over a 2:1 acceleration range is 113 ft/sec to 108 ft/sec or about a 4.4 per cent variation. This variation is usually acceptable for applications in the field of aircraft and missiles.

EDITOR'S NOTE—Additional information on the design of escapements and other impulse devices may be found in "The Science of Clocks and Watches," by A. L. Rawlings, *Pitman Publishing Corp.*, New York 1948. The book also discusses the dissipation of energy by a swinging pendulum, accuracy of balance-wheel movements, and friction and lubrication in clock mechanisms.

Design Hints for Laminated

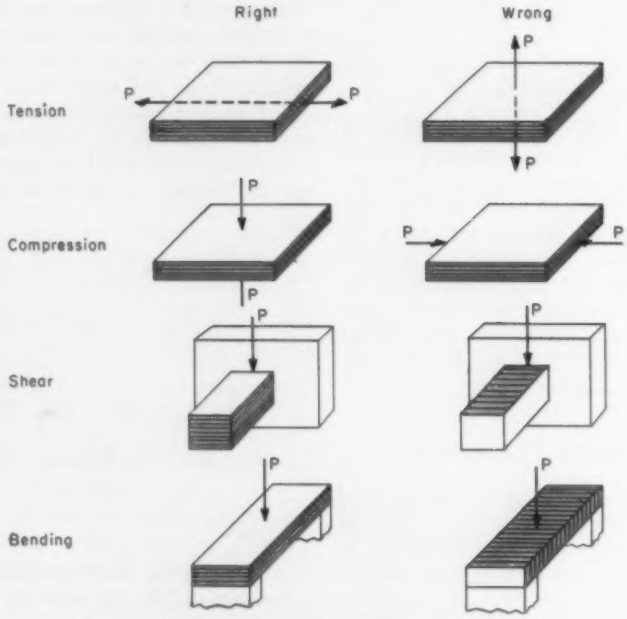


Fig. 1—Direction of loading in relation to laminations is important. Designs in which loads tend to separate or buckle laminations should be avoided wherever possible.

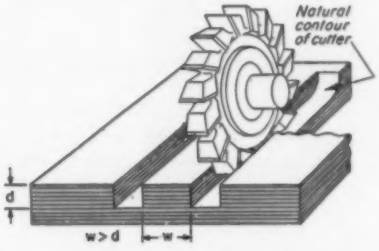


Fig. 2—Width of milled slots should be greater than depth, otherwise ridge between slots is liable to split or break off entirely. Also, milled slots should not be stopped with square corners. Allow bottom of slot to emerge to surface with natural contour of cutter.

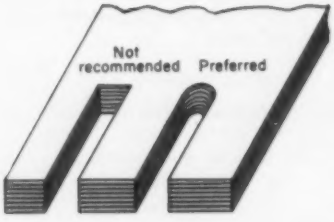


Fig. 3—Slot ends should be designed with rounded or radial end rather than square whenever possible. This permits use of end milling cutters to avoid added cost of filing and other finishing.

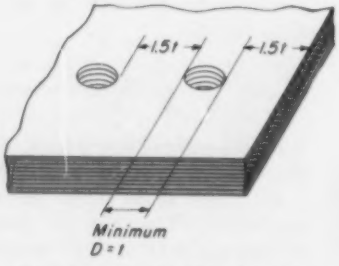


Fig. 4—Punched holes should always be located with at least 1.5 t between hole and edge of material. Hole diameter should never be less than thickness of sheet; punch breakage is liable to occur for smaller diameters.

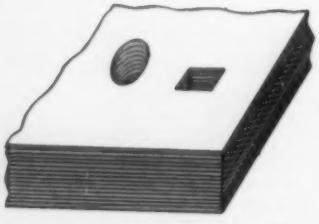


Fig. 5—Irregularly shaped holes should be avoided unless the piece is thin enough to allow the holes to be punched. Special tools or additional operations are necessary for irregular holes in thick material.

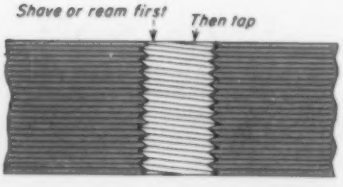


Fig. 7—Tapped holes should be shaved or reamed before tapping otherwise edge of threads will be rough and a screw insert may not fit properly. Tapping should not be specified closer than a class 2 fit with 65 per cent to 70 per cent thread.

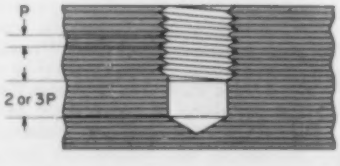


Fig. 6—Tapped, blind holes require a clearance of two or three times thread pitch at bottom of hole, otherwise threads will be stripped or slight delamination will occur.

Plastics

For economical production, thermosetting resins with laminar fillers require special considerations in design

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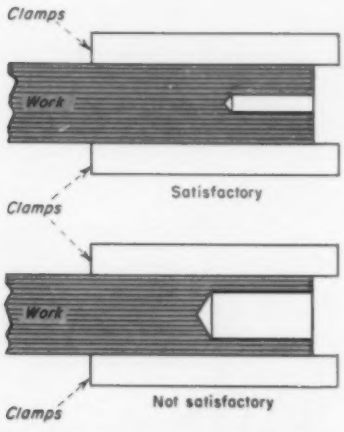


Fig. 8—Holes parallel to laminations should have ample wall thickness, especially where subsequent pressure, as from screw, might separate laminations. Work should always be clamped tightly when drilling and tapping.

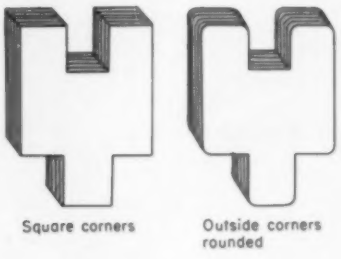


Fig. 9—Corners on punched parts should be rounded to avoid fractures. Sharp outside corner fractures may extend to about 1/3 material thickness from punched edge (varying with grade and die clearance.) If square corners are essential part may be punched large and fractures removed by shaving.

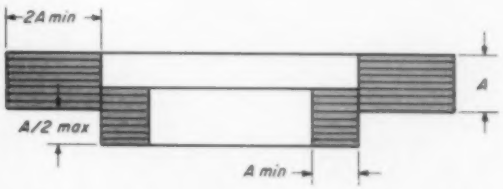


Fig. 10—Insulating washers in which center washer is partly punched through should have outer wall width in excess of twice laminate thickness; inner wall width should be at least equal to laminate thickness. Both walls may split if not wide enough. Inner washer may pop out if punched more than half-way through.

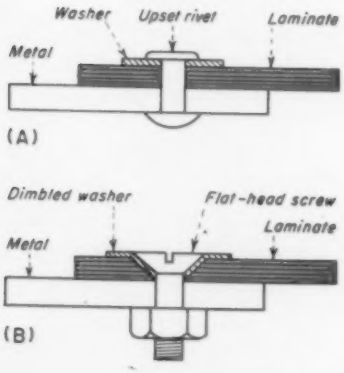


Fig. 11—Fastening and joining. (A) Tendency of rivets to pull through thin laminates may be reduced by using a flat washer under upset head where upset head is on plastic side. Washers reduce possibility of cracking in applications where minimum recommended edge distances cannot be met and upset head is on plastic side. Allow more edge distance (Table I) for riveted parts than shown in Fig. 3 to avoid splitting during riveting. Also limit rivet diameter to 5/32 in. or less. (B) Dimpled washers are useful for flush screw applications where the minimum recommended thickness for countersinking cannot be met. (C) Countersinking details, including Table II giving the minimum thickness of laminations for various rivet and screw sizes.

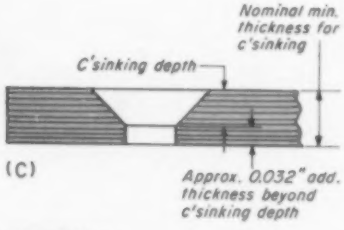


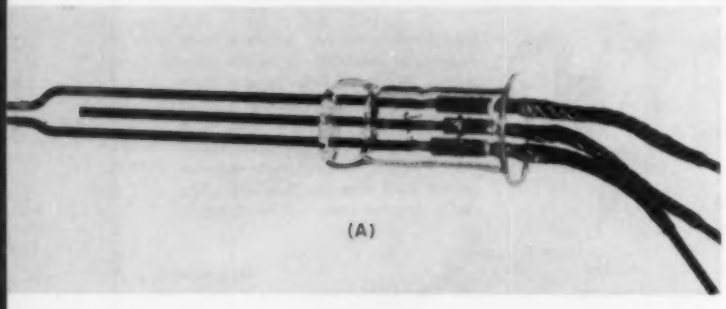
Table I - Edge Distance for Riveted Holes

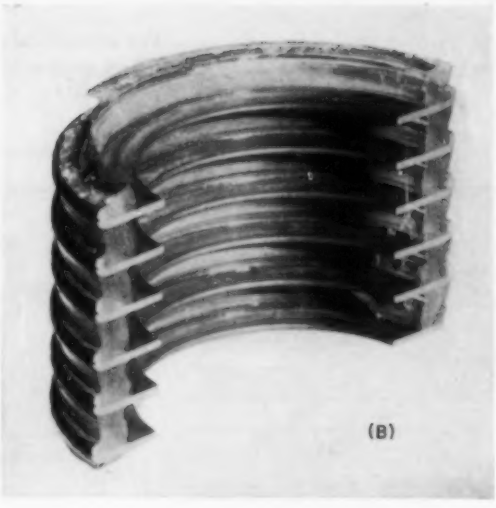
Rivet diameter	Thickness of laminate	Edge distance (min.)
3/32	1/8 or less	9/32
	Over 1/8	1/4
1/8	3/16 or less	3/8
	Over 3/16	5/16
5/32	1/4 or less	15/32
	Over 1/4	13/32

Table II - Minimum Thickness for Countersinking

Rivet size, in.	3/32		1/8		5/32	3/16						
Screw size		#4		#6			#8	#10	1/4"	5/16"	3/8"	7/16"
Min. nom. thick. for 100° c'sinking (in.)	0.070	0.080	0.080	0.090	0.090	0.100	0.110	0.125	0.140	0.190	0.220	0.225

Fig. 1—High power tube filaments (A) show expansion match seal between tungsten and glass. Oxidation of metal must be closely controlled before sealing to avoid weakening joint by scaling as temperature changes. (B) shows section of high voltage X-ray tube with Kovar metal rings precisely spaced by glass. Thermal coefficient match is required to maintain joint integrity during diametral expansion. Tube contains up to 300 Kovar rings.





Glass-to-Metal Seals

Five types of seals, design factors in selecting glass-to-metal seals, alternates to gasketed sight glass assemblies.

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GLASS AND METAL are normally considered distinctly different engineering materials. Glass is an amorphous "frozen liquid" extremely strong under hydrostatic loading. Metals are crystalline structures which flow under pressure. When a metal must be sealed to a glass, the characteristics of each as a fusing and bonding material must be compatible.

With certain exceptions, glass-to-metal seals should meet the following conditions:

(1) The glass should wet and adhere to the metal,

(2) Linear expansion of glass and metal should closely match over a wide temperature range,

(3) Thermal critical points of the metal must lie outside the service temperature range, and

(4) Glass should not reboil nor metal de-gas during sealing.

While the light bulb seal was easily achieved, the sealing of other glass-metal combinations proved more difficult. Glasses other than the lime type, such as lead, borosilicate and 96 per cent silica were thought to require gaskets for sealing to metals. Now, direct sealing of these glasses to metals is economically feasible by several techniques which are discussed individually.

A glass-to-metal seal will be one of the following five types:

Expansion match seals are fusion joints between glass and metal where the linear coefficient of both materials are identical, or nearly so. In practice, exact coefficient matches are difficult to achieve. Even the so-called high expansion types such as soda lime and high lead glasses have low coefficients compared to metals. Usually, the metal component material has already been selected, and the closest matching glass must be accepted. However, when a selection of metal is possible, matching combinations of metal and glass may be selected from the table.

The nature of the bond between glass and metal is not yet completely understood; however, the strength of the interface bond is believed to depend upon the availability of oxygen to the two surfaces during sealing. Oxygen is present in the oxide coating on the metal, and will partially dissolve into the glass. Strength and hermetic integrity are highest when a thin, strongly adherent oxide coating remains at the interface. A thick oxide coating tends to scale from the metal, weakening the seal. Examples of expansion match seals are shown in Fig. 1.

Housekeeper-type seals (so named from the physicist who developed the technique) permit sealing metal and glass of different expansion coefficients. Key to this technique is thin sections and low modulus metals which allow dimensional changes to occur by deflection without

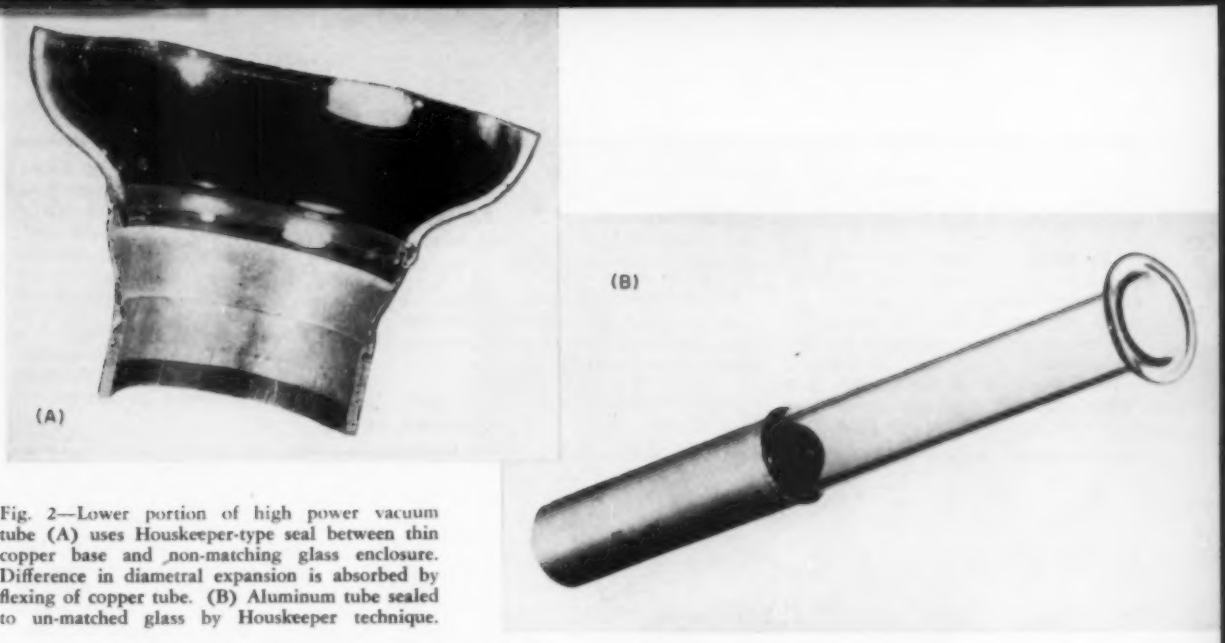


Fig. 2—Lower portion of high power vacuum tube (A) uses Houskeeper-type seal between thin copper base and non-matching glass enclosure. Difference in diametral expansion is absorbed by flexing of copper tube. (B) Aluminum tube sealed to un-matched glass by Houskeeper technique.

GLASS-METAL COMBINATIONS FOR EXPANSION MATCH SEALS

Metal or Alloy	Trade Name or Type	Matching Glass Corning	Remarks
Cold-rolled steel, AISI–C1010 SAE–1010	Other grades of soft steel or iron also used.	1990 1991	Tends to oxidize excessively. Plating with copper, chromium or silver often used to prevent oxidation.
17 per cent chrome iron	Allegheny Telemet		Used in TV picture tubes as a ring seal outside a glass plate of lower expansion.
28 per cent chrome iron	Allegheny Sealmet-1 Ascaloy–446 Carpenter–27	9012	Used in TV picture tubes. Alloy should be pre-oxidized in wet hydrogen gas.
Platinum		0010 0080 0120 7570 8160 9010	Used mainly for scientific apparatus. Pre-oxidizing unnecessary.
Clad wire, Core: 42%Ni, 58%Fe Sheath: Cu	Dumet		Wire size limited to 0.020 in. diameter. Surface usually coated with borax to reduce oxidation.
Nickel-chrome-iron 42% Ni 6% Cr 52% Fe	Sylvania No. 4 Allegheny Sealmet 4C-4 Carpenter-426		Suitable for large seals. Alloy should be pre-oxidized in wet hydrogen gas.
Nickel-cobalt-iron 28% Ni 18% Co 53% Fe	Kovar Femico Rodar	7040 7050 7052 7055 8830	Low-expansion sealing alloy. Should be annealed after cold-working and pre-oxidized in wet hydrogen gas.
Molybdenum		7040 7052	Metal rods ground and polished. Clean in fused nitrite. Avoid over-oxidation.
Tungsten		3320 7050 7720 8830	Same as for molybdenum.
Copper	Oxygen-free, high-conductivity grade	Most glasses	Housekeeper technique preferred. Avoid over-oxidation.

failure. For example, a metal tube is scarfed at one end to provide a wedge-shaped section only a few mils thick at the edge. The seal is made by initially beading this edge with "solder" glass, then sealing a tube of matching glass to the bead. Care must be taken to avoid over-oxidation of the metal tube. Two Housekeeper seals are illustrated in Fig. 2; this type seal is primarily used in glass-to-metal tubing arrangements.

Graded seals are short sections of glass tubing made up of thin layers—each with different thermal coefficients in descending order. Firing these layers together yields an intermediate link which permits joining a glass and metal whose coefficients differ widely. The X-ray tube cathode (A) in Fig. 3 shows the graded sealing of two such materials. A special type of graded seal made of powdered glasses, shown in (B), is presently being used

Application of glass-to-metal seals to refrigerant fittings and coffee urn illustrate principles of proper seal selection.

EXAMPLE: A sight glass was required for a refrigerant line. The first model used a gasket seal. Several materials were tried, but the refrigerant attacked the gasket resulting in leakage. An expansion match seal was tried: a window fused in a Kovar ring was simply soldered into the fitting. Although an improvement, this sight glass could not be used above the solder melting point, and high pressures caused failure at the soldered joint. The Housekeeper seal could not be used because of excessive metal thickness.

SOLUTION: An internal seal as shown in Fig. 4(B); extraneous materials were eliminated and a pressure safety factor of 10 obtained.

EXAMPLE: A coffee urn design specified a sight glass; an internal seal seemed to be the solution. However, the sight glass had to be mounted in a compound metal assembly previously silver-brazed together. Since the temperature reached during the installation of the window exceeded that of the silver solder, the internal seal could not be used.

SOLUTION: A metallized window similar to that in Fig. 5(B) soldered in place with a relatively low-temperature solder.

Fig. 3(A)

Fig. 3—Graded seal in X-ray cathode tube (A) joins Kovar through four grades of glass to Corning 7740 Pyrex brand glass. (B) Bands of powdered glass, each with a different expansion coefficient, are pressed together and fired for this special graded seal; used in difficult applications where a metal of high expansion must be joined to a glass of low expansion.

Fig. 4—Two varieties of internal seals for sight glasses are shown in (A). Neither solder nor gasket is required; glass is hermetically sealed to the metal. Large window has 4½ in. diameter; plug is ⅛ in. pipe size. (B) Brass refrigeration line fittings with internally sealed sight glasses. This design gave safety factor of 10 on line pressure. Other feasible metals include stainless and carbon steels.

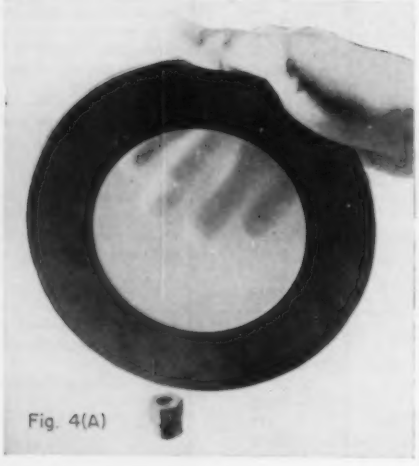


Fig. 4(A)

Fig. 4(B)

to seal tungsten wire to Vycor brand glass. This is an extremely low expansion glass used in ultra-violet ray tubes for its high transmission in the ultra-violet range.

A new seal has been developed for use where conditions do not permit either an expansion match or Housekeeper-type seal. Termed internal seals, these combinations are primarily used for sight glasses where gaskets are undesirable. The wide size range possible with internal seals is illustrated by the ⅜ in. pipe fitting and 4½ in. sight glass shown at (A) in Fig. 4; refrigeration equipment fittings (B), show the advantage of internal seals in applications where space is limited.

Pressure between glass and metal in the internal seal produces frictional forces sufficient to withstand extreme lateral pressures. For example, one design with a glass element ¾ in. diameter and 0.040 in. thick withstood a test pressure of 30,000 psi. Failure of internal seals under pressure is characterized by crazing of the glass

Fig. 5—(A) Metallized glass lens ready for soldering into sheet metal bezel. Semi-rigid frame minimizes stresses in glass and glass-metal bond since loads from primary structure are not transmitted to lens. Metallized seals are not necessarily hermetic. (B) shows electrical stand-off bushings being soldered in place. Iron does not touch metallized film; solder is feathered away from metallizing. Caps or flanges may be similarly attached to glass tubing.

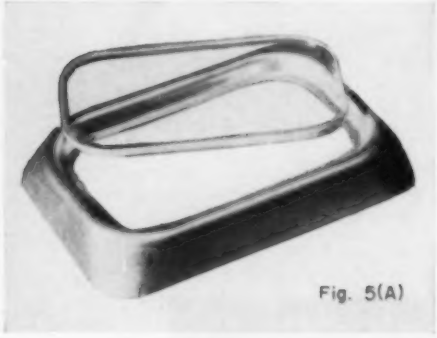


Fig. 5(A)

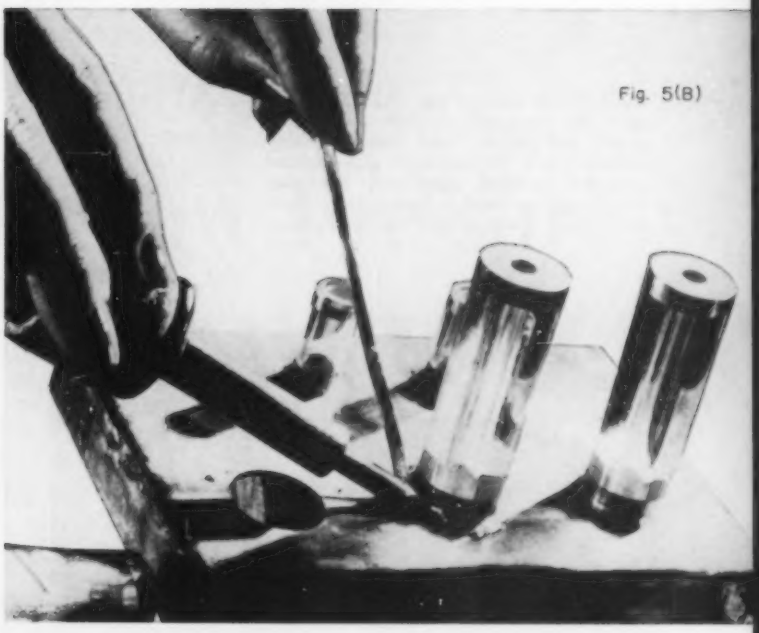


Fig. 5(B)

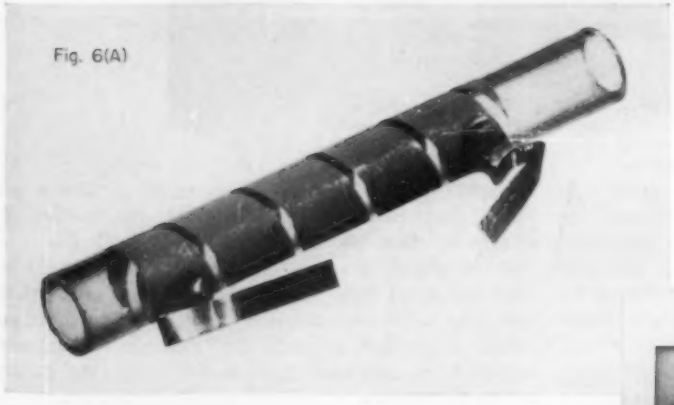


Fig. 6(A)

Fig. 6—Metallized glass inductance (A) with soldered leads. Combination of selected glass and fired-on conductor is valuable for high-frequency tuning applications requiring temperature stability and low loss. Printed circuit on Fotoceram, a photosensitive glass is shown in (B). A developed image shows preferential acid solubility, thus precisely etched circuit pattern can be metallized to give flush surface and minute terminal holes can be cut.

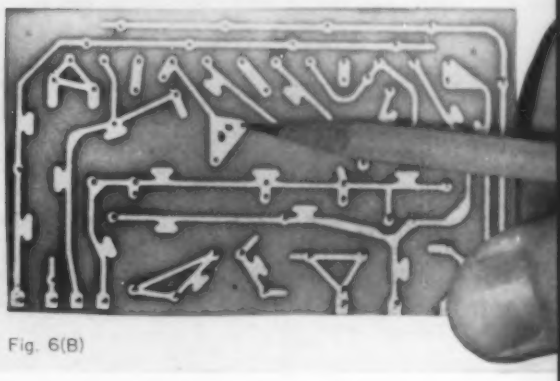


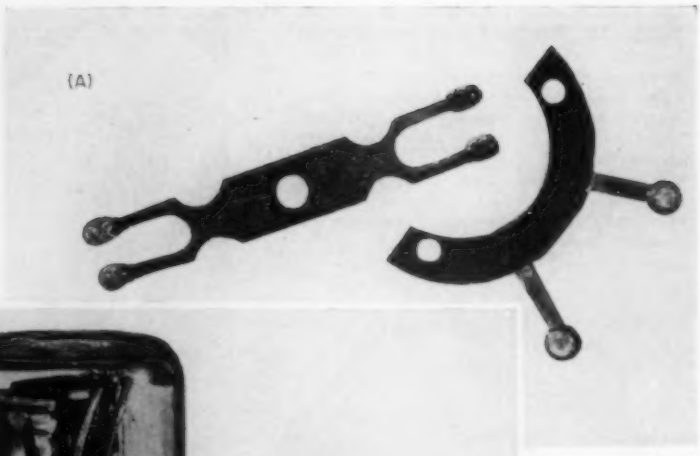
Fig. 6(B)

rather than by blowout, suggesting the use of this type seal for permanent record of overpressure.

Metallized glass seals reverse the Housekeeper principle by applying the metal to the glass. A "paint" is applied made from finely divided particles of a noble metal such as silver, together with glass fluxes suspended in an essential oil. Although the silver-flux mixture migrates into the glass upon heating, enough metal remains to present a base for plating additional metal. As in all Housekeeper-type seals, the metal thickness cannot be great (not over 0.002 in.) or the metal will spall from the glass. However, this thin film presents a good working base for soldering the glass element to other metal parts as shown by the two applications in Fig. 5.

Metallized glass technique is used for purposes other than mechanical support by combining the electrical conductivity of the metal film with the non-conductivity of glass. Precise inductances for high frequency tuning applications, like the one shown at (A) in Fig. 6, are produced by metallizing glass tubing and etching away undesired metal. These inductances have negligible drift under wide fluctuations in service temperature. Printed circuits metallized on Fotoceram glass, as in (B) of Fig. 6, may be used at temperatures up to 480 F.

Combinations of sealing methods are often required. The high power tube filament seal in Fig. 1 (A), for ex-



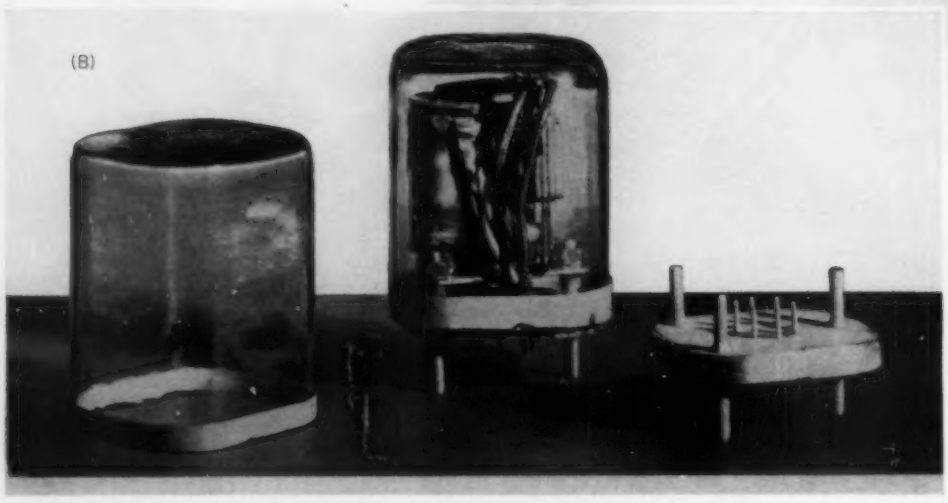


Fig. 7—Relay actuator bars (A) tipped with glass to withstand elevated temperature service and provide hard, smooth bearing surfaces. (B) Experimental glass-enclosed relay for elevated temperature operation. Note metallized band at bottom for closure. Transparent case simplifies trouble-shooting.

ample, combines the expansion match and the graded seal. The glass matching tungsten has a very low thermal expansion coefficient compared to the glass bulb which will be joined to the bell surrounding the filament leads; hence a graded seal is used to make the transition. The X-ray cathode of Fig. 3(A) is joined to a graded seal by a Housekeeper-type seal.

Design factors in selecting glass-to-metal seals: (1) Metal should be selected to fit the glass. Although there are thousands of glasses from which to choose, the variation in expansion coefficients is much narrower than for metals. (2) Metal mass controls the choice if an expansion match cannot be made. Large metal masses dictate internal seals; thin sections permit use of Housekeeper or metallized glass seals. (3) Metals of high thermal conductivity should be chosen to keep heat away from glass if installation or service temperatures are high. (4) High pressures indicate the use of either expansion match or internal seals.

Trends: The properties of metals are well known; glass, with its unique properties, is gaining wider acceptance as an engineering material. Using proper glass-to-metal sealing techniques, combinations of the two can provide an economical and often unique solution to many design problems. For example, many electrical relays are now required to function at temperatures as high as 750 F. Organic insulators such as epoxys and phenolics will not withstand these temperatures, and are in many instances being replaced with glass, as shown in Fig. 7. The relay actuator bars shown in (A) have their bearing points tipped with glass. The experimental relay shown in (B) replaces the usual soft-soldered hermetic metal can with an all-glass enclosure, metallized at the bottom for closure by silver brazing.

Fixed capacitors are being made of expansion matched glass and metal layers fused into monolithic unit. Metalized glass inductances are stable at high temperatures and exhibit a very low dielectric loss. Resistors and trimmer-capacitors are also made from glass-to-metal combinations for similar reasons.

If material specifications call for good electrical insulation, transparency, resistance to high temperatures or thermal shock, and corrosion resistance, a glass-to-metal seal may be the solution.

EDITOR'S NOTE—Previous articles in *Product Engineering* of use in designing glass and metal components include the following:

"New Industrial Uses for Glass," June 1955 page 129. Good introduction to glass as an engineering material. Properties are tabulated for 5 main glass types, including a new 96 per cent silica composition for high temperatures.

"Glass-to-Metal Hermetically Sealed Terminals," February 1955 page 180. Improvements in strength and reliability of this type terminal have greatly increased applicability, particularly in miniaturization problems. Types of terminals and methods of application.

"Vibration Damping Characteristics of Glass Fiber Cushioning," February 1954 page 200. Charts showing load-deflection characteristics of glass fiber mat, hysteresis, transmissibility-frequency characteristic, shear strength data and effects of temperature on performance.

"Methods of Attaching Glass to Metal Structures," July 1952 page 166. Diagrams detailing pipe joints, sight glasses, threaded joints and O-ring seals.

Limitations on

Cam Pressure Angles

Selection of maximum pressure angle based on distribution of forces in the cam follower. Four types of cam followers are analyzed: overhead, system with a secondary follower, flat-faced follower, oscillating roller.

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SYMBOLS

A = follower overhang, in.
B = follower bearing length, in.
F = force normal to cam surface, lb
F_y = force along the centerline of the stem axis
L = total external load on follower (includes weight, work loads that the follower is operating, spring, inertia, friction), lb
M = moment, in.-lb
N = force normal to the follower stem
R = radius of follower stem
α = pressure angle, deg
α_m = maximum pressure angle, deg
μ = coefficient of friction between follower stem and its guide bearing

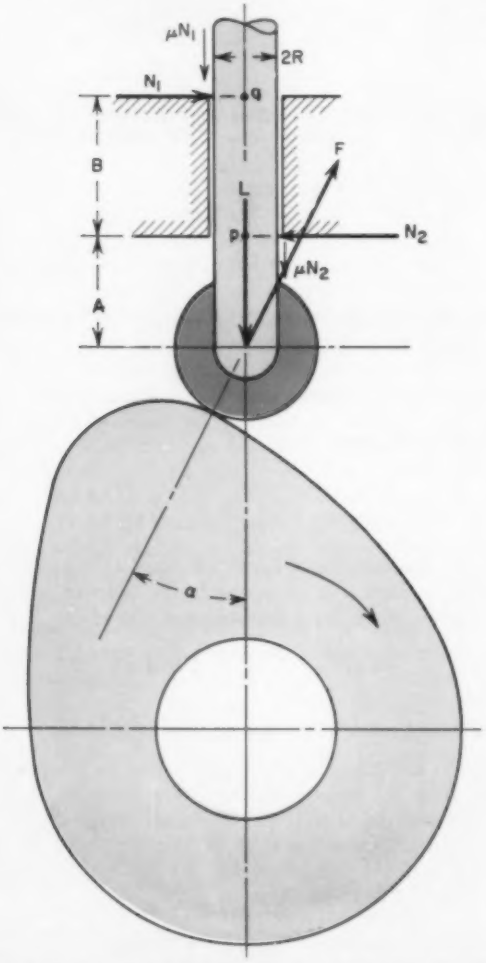

Fig. 1—Although the pressure angle α influences the size, operating speed and wear life of the cam, it is in turn influenced by the distribution of forces in the follower.

ONE OF THE INITIAL STEPS in cam design is the selection of a maximum pressure angle. This decision is usually performed somewhat arbitrarily and is based on judgment and experience. The selection will affect the size, contour, operating speed, wear and life of the cam. The effect of the maximum pressure angle on all these factors has been analyzed mathematically in detail (see Editor's Note at the end of this article) but little attempt has been made to analyze mathematically the factors that limit the maximum value of the pressure angle.

Limitations on the pressure angle are primarily caused by the distribution of forces in the follower. Referring to Fig. 1, pressure angle α is the angle between the centerline of the follower and the normal to the cam surface at the point of contact between follower and roller.

If the cam in Fig. 1 has a pressure angle of 45 deg at one point of its motion, it can be seen that there is a strong possibility that the clockwise rotation of the cam would not cause the follower to rise but to jam against the guides causing bending in the follower stem.

Standard practice has been to arbitrarily limit the pressure angle to 30 deg. Then after the type of motion (parabolic, harmonic, etc.) and the operating speed of the cam is selected, the effect of the 30 deg pressure angle on various cam factors is analyzed. If the analysis predicts some undesirable effects such as high stresses in the cam surface or jumping of the cam follower, the pressure angle is reduced. If the analysis, however, validates the initial decision, the maximum pressure angle is accepted and the design proceeds to the next stage.

It might have been quite possible and desirable, in

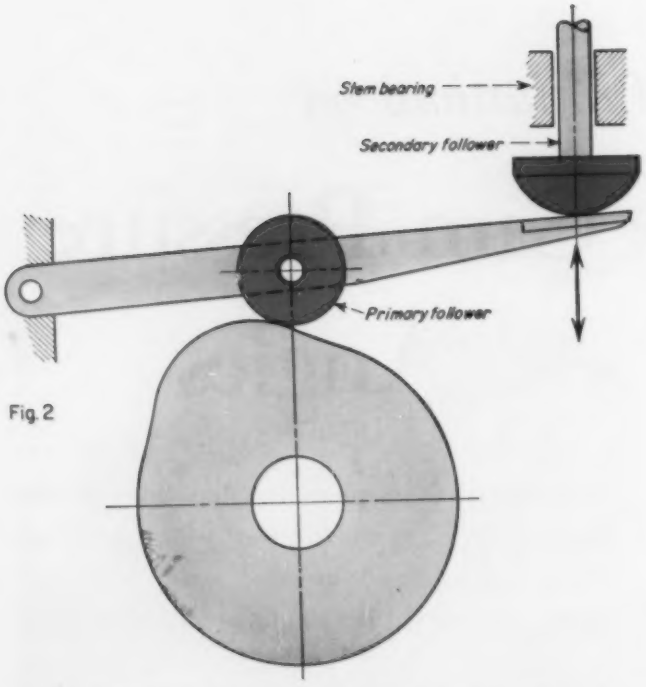

Fig. 2

Fig. 2—Cam system with a secondary follower has little side thrust against the stem bearing; therefore, jamming of the follower is almost impossible.

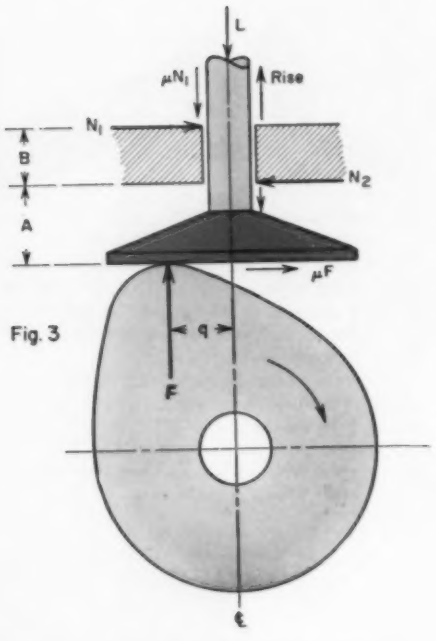

Fig. 3

Fig. 3—Pressure angle in a flat-faced follower is always zero. Side thrust is negligible.

the above case to use a pressure angle larger than 30 degrees. In a recent article, "Minimum Cam Size as Determined by Pressure Angle," *Product Engineering*, July 1956 page 141, it was shown that an increase in the pressure angle can directly reduce the cam size, while keeping its contour similar. If the overhang of the cam follower is small, and the cam follower rigid, the maximum pressure angle may be increased to 40 or even 50 degrees.

Effect of Side Thrust

In the following equations it will be shown that the pressure angle is limited by the length of the follower overhang, its guide bearing length, the rigidity of the follower stem, and the coefficient of friction between the follower stem and the guide bearing.

It is safe to assume that the friction in the follower roller bearing is negligible—especially with the modern tendency to use anti-friction roller or ball bearings (see "Design of Cam Followers," September 1956 page 197). Referring to Fig. 1, the sum of the forces along the vertical axis (the y-axis) must equal zero:

$$F_y = F\cos\alpha - L - \mu N_1 - \mu N_2 = 0 \qquad (1)$$

If points p and q are the intersections of N_1 and N_2 with the follower stem centerline, the sum of the moments around each point will be

$$M_p = 0 = -FA\sin\alpha + N_1B - \mu N_1R + \mu N_2R \qquad (2)$$

$$M_q = 0 = -F(A+B)\sin\alpha + N_2B - \mu N_1R + \mu N_2R \qquad (3)$$

Assuming that the difference between N_1R and N_2R is almost zero, the last two terms in Eqs (2) and (3) cancel each other out and the equations reduce to:

$$N_1 = \frac{A}{B}F\sin\alpha \qquad (4)$$

$$N_2 = \frac{A+B}{B}F\sin\alpha \qquad (5)$$

Substituting Eqs (4) and (5) into Eq (1) to eliminate the N_1 and N_2 terms results in:

$$F\cos\alpha - L - \mu\left(\frac{A}{B}F\sin\alpha + \frac{A+B}{B}F\sin\alpha\right) = 0 \qquad (6)$$

Rearranging terms gives:

$$F = \frac{L}{\cos\alpha - \mu\left(\frac{2A+B}{B}\right)\sin\alpha} \qquad (7)$$

If the denominator of Eq (7) is equal to zero, force F becomes infinite. In other words the follower will jam in its guide when the following condition exists:

$$\cos\alpha - \mu\left(\frac{2A+B}{B}\right)\sin\alpha = 0$$

$$\alpha_m = \tan^{-1}\frac{B}{\mu(2A+B)} \qquad (8)$$

Eq (8) will generally give higher values for the pressure angle than are usually selected. For example if A is approximately equal to B and the values for the coefficient of friction of bronze on steel is: (kinetic) = 0.10, and (static) = 0.15; then, from Eq (8) the maximum pressure angle for each condition is:

$$\alpha_m = \tan^{-1}\frac{1}{3(0.10)} = 73.5 \text{ deg}$$

$$\alpha_m = \tan^{-1}\frac{1}{3(0.15)} = 66 \text{ deg}$$

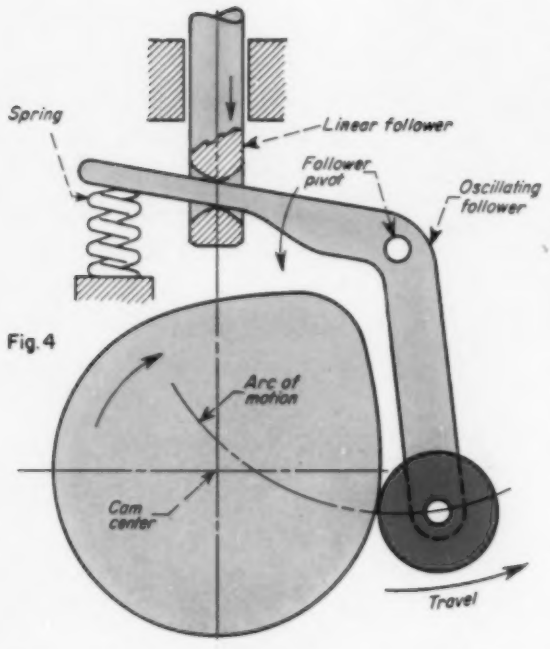

Fig. 4—It is almost impossible to cause jamming in a cam system with an oscillating follower. Therefore, size of cam can be greatly reduced.

Derivation of Eq (8) is based on the ideal assumption that the stem of the follower is perfectly rigid. A flexible stem may dig into the lower corner of the bearing. Thus the coefficient of friction for the above case may actually reach a value of 0.25 or more depending upon the flexibility of the follower stem and upon the amount of clearance (backlash) between stem and stem bearing.

Therefore, the coefficient of friction μ, the follower overhang A, and the bearing clearance should be kept as small as possible, and the bearing length B as large as possible. Ball bushings for the linear moving stem are commercially available to give very low friction and backlash. In addition, the follower stem should be made rigid. Fulfilling these requirements will give the largest pressure angle and the smoothest follower action possible. With light loads and low-friction bearings the author has successfully used pressure angles as high as 47½ degrees.

Jamming of the follower is only of concern when the follower moves in a direction opposite to that of the external load L. Referring to Fig. 1, jamming occurs during the rise period only. During the fall period, the size of the maximum pressure angle is generally not limited. However, there are cases whether the follower has driven the cam during the fall action. For example, with a chain-driven cam, a spring-loaded follower dropping on an excessive pressure angle of fall, can produce detrimental shock and fluctuating action especially if there is substantial clearance between the follower and its guide.

In changing from rise to fall, the reactions N_1 and N_2 will reverse their directions to the other side of the follower stem. This necessitates that the clearance between the follower and its bearing guide cshould be kept to a minimum to limit the noise and shock.

All of the foregoing discussion refers to an offset follower as well although mathematical relations are not shown because of their complexity. The advantage of offsetting is that the pressure angle may be reduced during that portion of the action (rise or fall) which has the detrimental side thrust. Furthermore, decreasing the pressure angle in one portion increases the pressure angle in other less important portions of the cam action. Almost complete elimination in pressure-angle side thrust may be accomplished by using a secondary follower such as shown in Fig. 2. In this design the undesirable force components are prevented from jamming the follower and producing wear.

Flat-Faced Followers

Side thrust or jamming effect on flat-faced followers is inconsequential compared to roller followers because the pressure angle is zero. A flat-faced follower is shown in Fig. 3 with normal forces N_1 and N_2. Direction of N_1 and N_2 varies depending on whether the eccentricity q is on the right or left of the cam centerline. The pressure angle is zero at all times because the normal force F is always parallel to the cam centerline. Thus the cam size can be much smaller than if a roller follower is used.

Jamming of the follower is caused only by the net effect of the opposing moments of forces F and μF. Although for best performance, the ratio B/A should be kept large, coefficient of friction μ and eccentricity q should be kept small, and the rod rigidity as high as possible, these factors are not critical compared with the roller follower—which is an inherent advantage of the flat-faced follower.

Oscillating Roller Follower

The oscillating roller follower in Fig. 4 is an improvement over the flat-faced follower in that the distribution of forces allows a much larger limiting pressure angle for satisfactory performance. Thus, with an oscillating follower, a smaller cam may be used.

For best performance and highest accuracy the arc of motion should pass near or through the cam center. Also, by proper location of the follower pivot, it becomes virtually impossible to jam the follower, no matter how steep the cam surface. The extreme limiting condition is to make the pressure angle small enough to prevent the cam normal force from passing through the follower pivot. This often requires frequent trials by layout to establish the best dimensional proportions under the given design conditions.

EDITOR'S NOTE—Effect of the maximum pressure angle on various cam design factors has been analyzed in recent articles:

"Minimum Cam Size as Determined by Pressure Angle," July 1956 page 141.

"Plate Cam Design—Evaluating Dynamic Loads," January 1956 page 179. Evaluating the inertia loads on the cam system when the cam profile, speed and pressure angle are known.

"Plate Cam Design—Pressure Angle Analysis," May 1955 page 155. Relationship between pressure angle, type of cam profile (cycloidal, harmonic, eight-power polynomial) and allowable compression stresses in a plate cam.

"When Will a Cam Follower Jump," July 1954 page 156.

See also recent text "Cams—Design, Dynamics, and Accuracy," reviewed December 1956 page 361.

HYDRAULIC CONTROL VALVES

Following the first article in this series on relief valves which appeared in December 1956 this installment describes counterbalance valves, sequence valves, unloading valves, and pressure reducing valves. Construction details, operational idiosyncrasies, drainage and circuit application are included.

II—Pressure Control Valves

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ALL PRESSURE CONTROL VALVES, including relief valves, are basically two-way valves held normally open or closed by a spring or equivalent device (counterweights or pneumatic balance). Either input, output or external pilot pressure may be used to control the valve by aiding or inhibiting spring force depending on the desired function.

Variations on the basic pressure control valve include compounding with check valves, providing alternate flow paths, or inverting the pilot connections to achieve specialized functions. Each application requires special consideration of the consequences of failure of the valve or of other components in the system. Every valve must be properly drained of clearance flow or it will not function as planned.

COUNTERBALANCE TYPE

Quoting from the glossary of terms for fluid power as published by the National Fluid Power Association, "VALVE, COUNTERBALANCE—A valve which maintains resistance against flow in one direction but permits free flow in the other. Usually connected to the outlet of a double acting cylinder to support its weight or prevent uncontrolled movement." Fig. 1 is an example of this type of circuit.

When the piston is lifted the counterbalance valve offers no obstruction to flow since the integral check valve permits free flow in this direction. When lowering, fluid coming out of the cylinder is controlled at a set minimum pressure by the pressure actuated segment of the valve. This means that the piston must be "pumped" down.

Flow from the counterbalance valve is usually connected through the directional control to tank. This permits the spring pocket to be internally drained saving piping and eliminating potential external leakage as shown in Fig. 2. Note that when the cylinder is lifting pressure is applied in the spring pocket of the pressure actuated segment of this valve closing it off tight. Reverse flow must go through the integral check.

When lowering, the check valve closes, so that flow is controlled by the pressure actuated segment which will not open until a set pressure is built up under the piston. The downstream or outlet port of the counterbalance valve is directed to tank so that the internal drain is also to tank and the pressure actuated segment of the

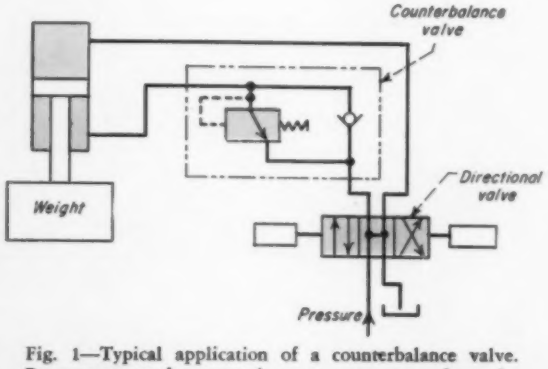


Fig. 1—Typical application of a counterbalance valve. Pressure actuated segment is set to open at or above the pressure generated in the trapped fluid under the piston by the load weight. To lower the weight the piston will then have to be "pumped" down.

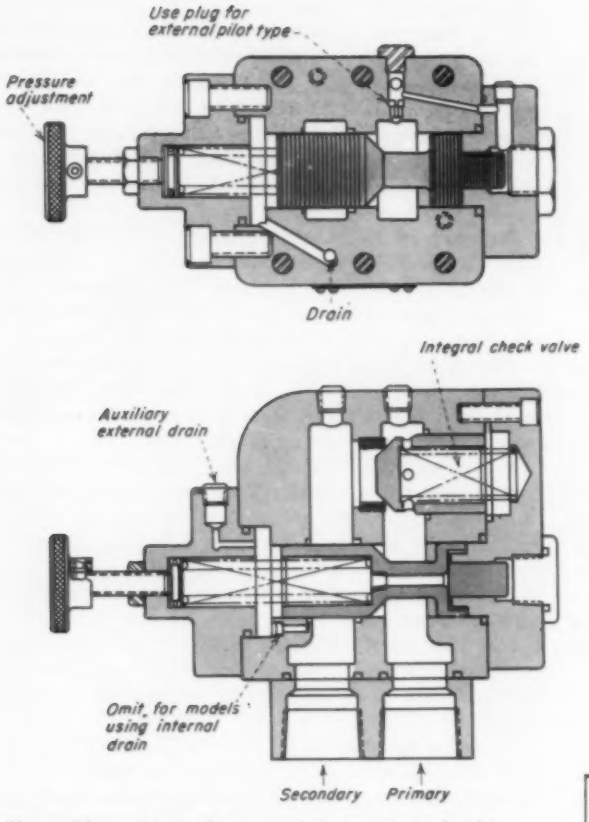


Fig. 2—Two sections of a counterbalance valve using internal drain. External connection to spring pocket is plugged and internal connection goes to secondary.

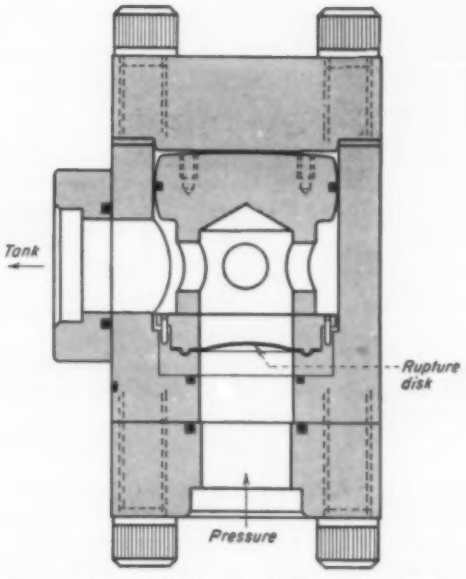


Fig. 3—A hydraulic fuse in which flexible disc will rupture above specified design pressures permitting free flow to tank.

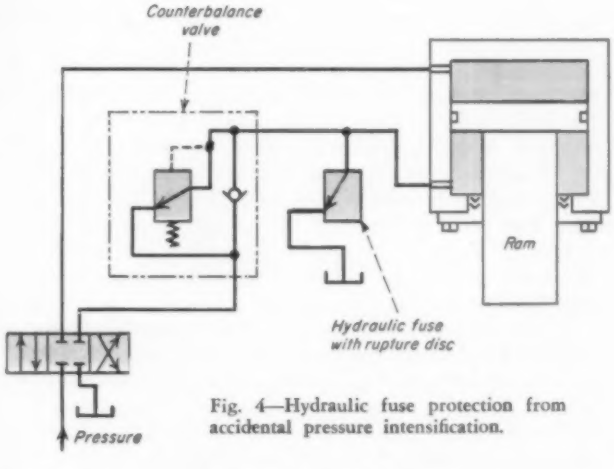


Fig. 4—Hydraulic fuse protection from accidental pressure intensification.

valve operates in a normal manner.

The actuating mechanism of the counterbalance valve may be operated from a control line internally connected to the primary port or from an external source. The direct operating type wherein the pressure is connected internally is generally used where it is desired to prevent uncontrolled movement of the cylinder.

A relatively light circuit may depend on the counterbalance valve as the only mechanism preventing cylinder drop during idle cycles. If loading on the cylinders is likely to change in value, as in the case of a control gate on a power dam covered with ice in the winter time, the pilot line from the counterbalance valve may be taken from the opposite end of the cylinder so that there would have to be pressure on the top of the piston before the counterbalance valve will open.

This connection has the further advantage of preventing a runaway condition that may develop in closely counterbalanced cylinders. When lowered, a high inertia load can maintain pressure under the piston even if pump pressure is cut off. If the counterbalance valve is piloted from this side of the cylinder it will remain open. If it is piloted from above the piston any drop in supply pressure will drop the pilot pressure so that the counterbalance valve will restrict movement to the speed of pump flow. A fast uncontrolled gravity drop is avoided.

In many circuits, especially press circuits, the counterbalance valve may be controlling oil coming out of jack rams or the lip of the main ram. If the pilot line is damaged or the counterbalance valve accidentally jammed with foreign matter there is a possibility of high pressure amplification factors. Recognizing this problem, provisions should be made to install a hydraulic fuse like the one shown in Fig. 3. Burst pressure of the hydraulic fuse should be based on maximum pressure that the packing on the lip of the ram or the jack ram or that mechanical linkages in the press can withstand.

The hydraulic fuse is always connected between cylinder and counterbalance valve with a suitable "tee" connection as shown in Fig. 4. In most installations the hydraulic fuse need not be large in physical size because high velocities are expected through the orifice after the disc has

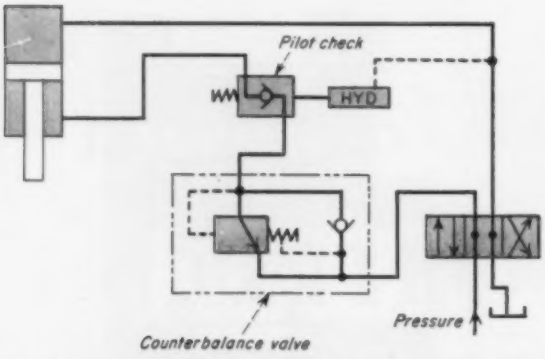


Fig. 5—The pilot check placed in series with a counterbalance valve prevents downward drift of piston until the upper face is pressurized.

burst. Contained pressures need not be dropped to zero but only to a safe limit established by the machine components. The extremely accurate burst values of the hydraulic fuses make it possible to choose one close to the maximum pressure allowable on the machine components. This factor makes it practical and safe to have a wide range between normal operating pressure and burst pressure of the disc.

When a mechanical counterbalance is used with a vertical cylinder the counterbalance valve would only be installed to prevent uncontrolled movements. If the counterbalance valve is the only mechanism to control the static position of a vertical cylinder perfect functioning becomes extremely important. Clearance flow through the valve in the static condition of the machine must be minimized since gravity drift of the cylinder will be a function of total clearance flow through valve plus clearance flow past cylinder rings. If no drift is permissible it may be necessary to provide suitable lock pin devices or ratchet mechanisms to make certain the cylinder does not drop during long static periods.

In vertical cylinder installations a pilot operated check valve and a counterbalance valve are sometimes installed in series as shown in Fig. 5. The check valve is normally piloted from the opposing cylinder line. The counterbalance valve may be either internally or externally piloted. The pilot operated check provides a tight seal without clearance flow during the static portion of the machine cycle. The counterbalance valve creates sufficient resistance during downward movement to prevent the pilot check from closing and reopening which would create chatter and shock waves in the machine cycle.

In some installations it is possible to use a poppet type pilot controlled relief valve as a counterbalance valve to minimize clearance flow during the static cycle. The balancing sleeve in the poppet type relief valve is a sliding fit so that even in this type of valve there will be a certain clearance flow.

SEQUENCE VALVES

From the glossary of terms for fluid power as published by the National Fluid Power Association: "VALVE, SEQUENCE—A valve which directs flow to more than one portion of a fluid circuit in sequence. Flow is directed only to that part of the circuit which is connected to the primary or inlet port of the valve until pressure setting of the valve is reached. At this time the valve opens and pressure in the secondary port may vary from zero to near the setting of the primary side with no variation in the primary pressure. If pressure in secondary equals primary setting, valve opens fully." Fig. 6 is a sectional drawing of a typical sequence valve.

Practically all sequence valves must be externally drained since the secondary portion of the circuit is pressurized during some functions. Excessive back pressure on the external drains would act as an additive to the spring adjustments creating an abnormal operating range.

Pilot signal for a sequence valve is generally from an internal source. However, if the sequencing operation must be interlocked with other portions of the circuit it may be necessary to use an external pilot.

If the sequence valve is "teed" between directional control valve and a second cylinder to provide a sequence of operations, the valve will normally be equipped with an integral check valve for a free flow in the opposite direction as in Fig. 2. If the sequence valve is used ahead of the directional control valve to insure a source of pressure to certain portions of the circuit the check would not be necessary. As shown in Fig. 7, any severe drop in main circuit pressure will close the sequence valve and guarantee a minimum pilot pressure to the pilot circuit.

There are installations in which it is necessary to prevent an uncontrolled low pressure movement of the cylinder in either direction. Fig. 8 illustrates a dual pilot

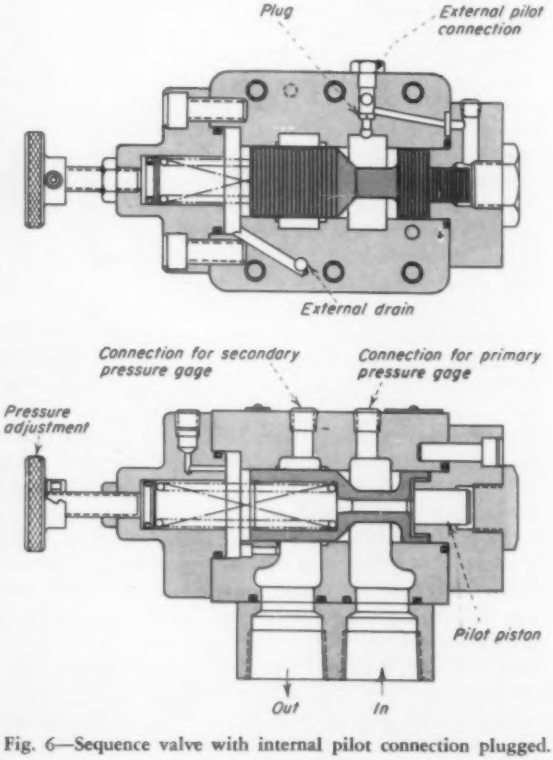


Fig. 6—Sequence valve with internal pilot connection plugged.

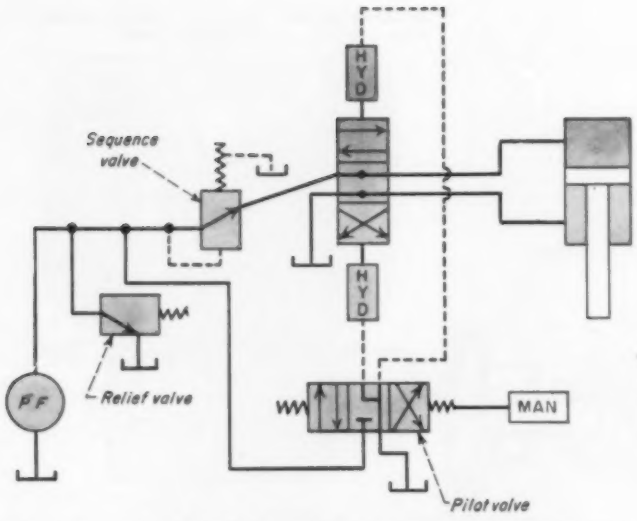


Fig. 7—Sequence valve is here used to guarantee a minimum pressure to the control circuit. Set to a low value the sequence valve closes only under unusual conditions in the main power circuit.

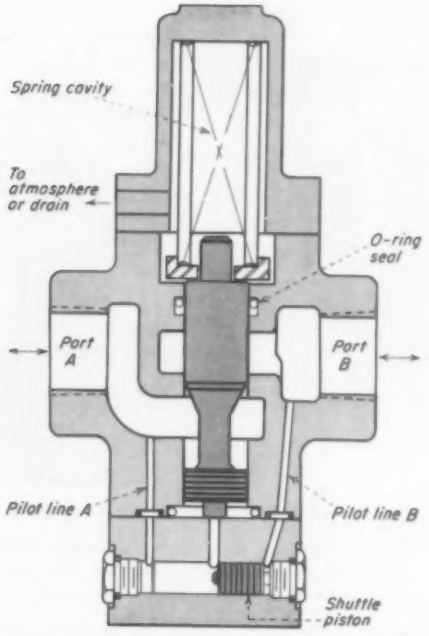


Fig. 8—This sequence valve operates identically for both directions of flow. Either way a minimum pressure is required to open the valve.

sequence valve which can be installed in one or both cylinder lines to keep the cylinder under control at all times. When port A is pressurized the shuttle piston is shifted as illustrated and a pilot line directs fluid to the bottom of the spool. This fluid under a predetermined pressure will cause the spool to rise against the spring and connecting ports A and B. If pressure diminishes in port A the spool will be closed by the spring. When port B is pressurized the shuttle piston will be shifted and the operation is reversed. The spring cavity may be drained to the tank or sealed tight with an O-ring on the spool as illustrated so that the spring chamber can be open to atmosphere.

This same dual pilot operated sequence valve can be used as a direct spring loaded dual relief valve between the cylinder lines of a double rod cylinder or fluid motor as a protection against over pressures. However, this unit makes no provision for replenishing fluid lost in certain functions of a fluid motor as some of the more complex dual relief and replenishing valve units do.

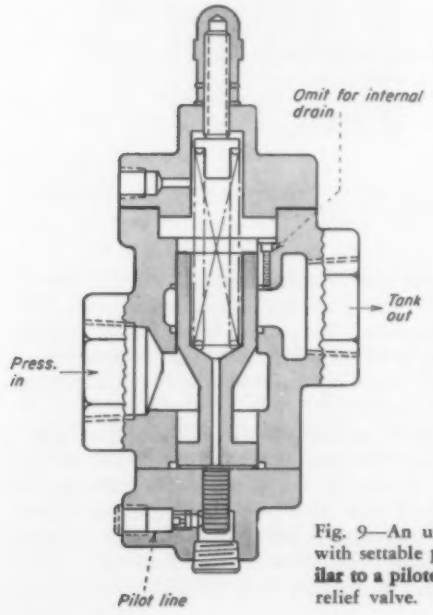


Fig. 9—An unloading valve with settable pressure is similar to a piloted low-pressure relief valve.

UNLOADING VALVES

From "A Glossary of Terms for Fluid Power" prepared by the National Fluid Power Association: "VALVE, UNLOADING—A valve which allows pressure to build up to an adjustable setting, then by-passes the flow as long as the present pressure is maintained on the pilot port by a remote source."

From this explanation the unloading valve can be a spring offset two-way valve which usually has an adjustment to regulate the tension on the spring that controls the pressure setting at which the valve opens. Fig. 9 is a typical unloading valve.

Since the unloading valve is generally used to by-pass a portion of the circuit back to the reservoir at a negligible pressure internal drainage of the spring pocket is possible. An exception to this would be the circuit wherein the by-pass type unloading valve is used to unload a high pressure circuit into a lower pressure circuit. In this case the pressure from the secondary, or lower pressure circuit might adversely affect the spring adjustment because of the additive effect of spring pocket pressure.

An unloading valve directly actuated by a pilot piston and balanced by spring compression has some basic disadvantages. Spring rate determines the range from cracking value to full open which is usually quite wide. In

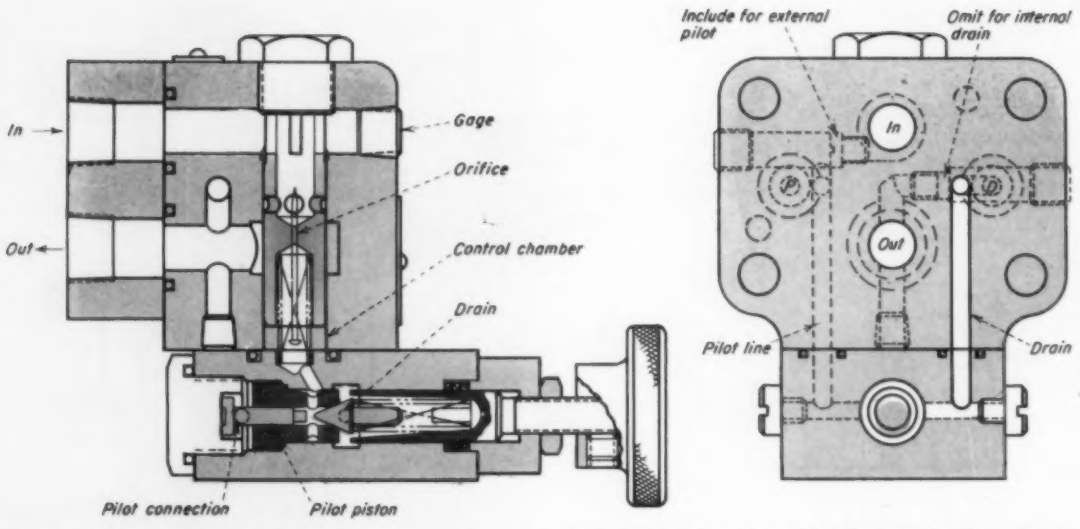


Fig. 10—Auxiliary pilot control unloading valve. Pressure is equalized across the main spool orifice. When pilot pressure is applied the pilot cone is lifted off its seat dropping spring pocket pressure to a low value. Main circuit pressure then overcomes the spring and flows to the outlet port.

addition, repetitive reset accuracy is limited. Where these factors become troublesome, a pilot operated sequence type unloading valve may be used in which the unloading valve is similar to a piloted relief valve and the pilot cone is forced off the seat by a small piston as shown in Fig. 10. Small physical motion is required from full open to full closed and the unloading cycle and the repetitive reset value are very accurate.

A disadvantage of the pilot chamber control type is that it will operate if inlet port pressure is high enough to lift the cone off its seat. In some applications this may be an advantage but it must be taken into consideration when choosing circuit components.

The pilot chamber control type has another possible disadvantage in that the minimum operating pressure required at the inlet port is somewhat higher than that of the direct spring balanced type after the valve is fully unloaded by the pilot source. The pilot chamber control type is built similar to a pilot operated relief valve and has its main spool relief spring effective during the unloading cycle. This low value, (usually less than 50 psi) may be high enough to cause overheating in certain circuits. Smaller valves are not usually affected by the high minimum pressure. A larger valve must drop to as low a value as possible so most are manufactured with direct spring loading. Fig. 11 is an example of this construction.

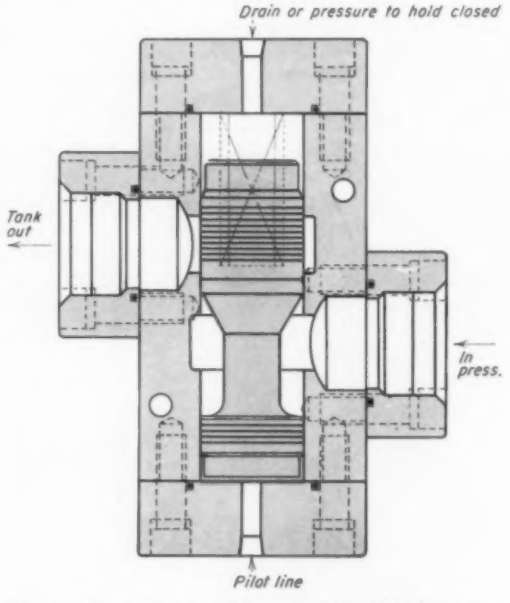


Fig. 11—Large capacity unloading valve with direct acting spring and pilot passages.

PRESSURE REDUCING VALVES

A pressure reducing valve is almost the exact opposite of a relief valve. A relief valve is a spring offset, normally closed, two-way valve with the sensing line to the inlet port. A reducing valve is a spring offset, normally open, two way valve with the sensing line taken from the outlet, or downstream line as shown in Fig. 12. Both valves may include certain damping devices as well as bleed orifices and other controls for most satisfactory service over a wide variety of applications.

The spool is held normally open with a balancing spring until the secondary, or reduced pressure, rises to the value of the spring and gradually lifts the spool. This lifting operation closes the passage between high pressure inlet and low pressure outlet and high pressure oil is prevented from reaching the secondary, or low pressure area.

Since the spool in this series is of the sliding type a certain amount of clearance flow can be expected between high pressure source and low pressure area. To prevent this clearance oil from increasing pressure in the secondary area, an adjustable bleed spigot may be provided. This bleed spigot is in effect a variable orifice. When the desired amount of bleed is established for satisfactory

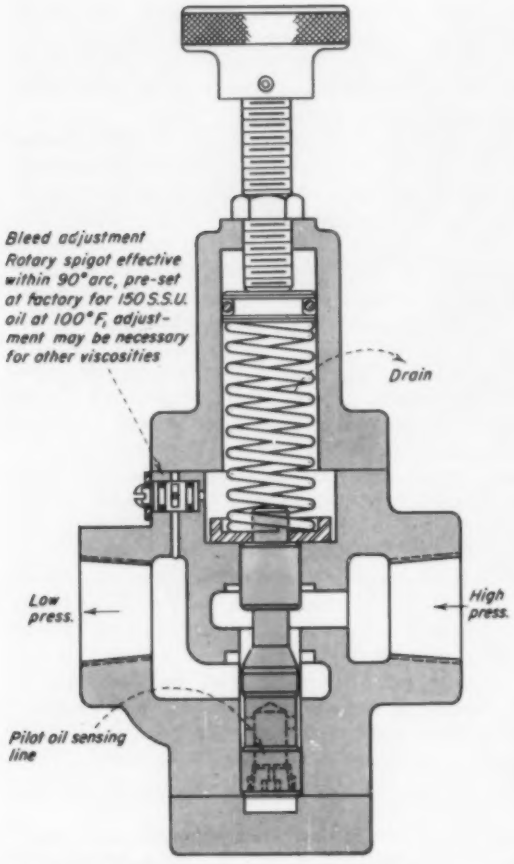
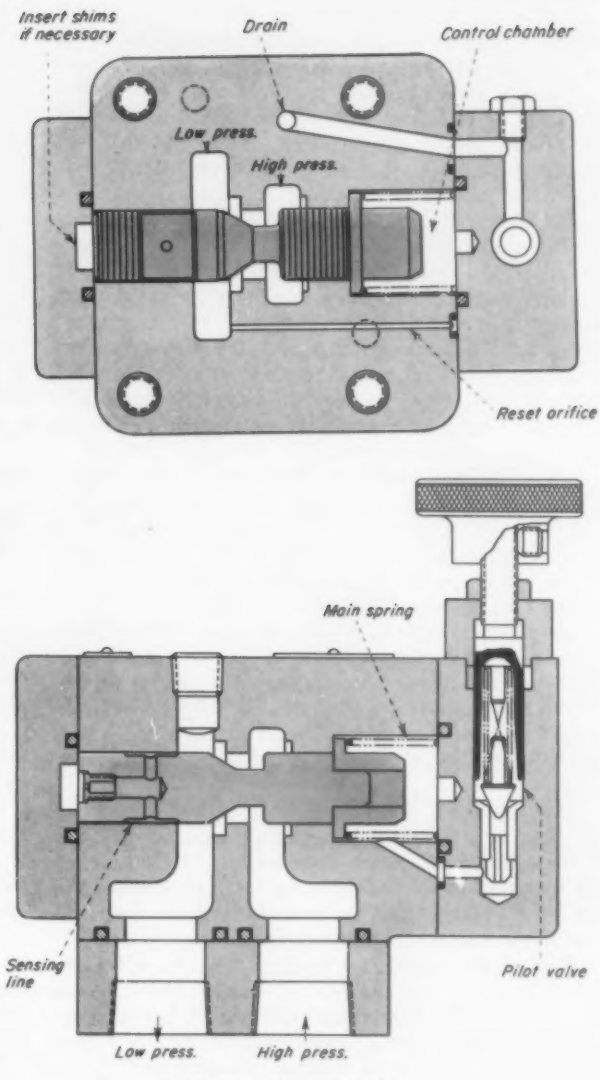

Bleed adjustment
Rotary spigot effective within 90° arc, pre-set at factory for 150 S.S.U. oil at 100° F, adjustment may be necessary for other viscosities
Drain
Low press.
High press.
Pilot oil sensing line

Fig. 12—A direct spring operated reducing valve in which oil from the low pressure connection is directed through an orifice to the back of the spool. As secondary pressure increases the valve is closed.



PILOTED REDUCING VALVE

Fig. 13—A piloted reducing valve with integral pilot to control oil pressure in the spring pocket. Tightening the pilot valve spring permits higher pressure to be developed in the spring pocket requiring higher secondary pressures to close off the main spool passage.

operation, it is locked in position. If there is adequate clearance flow in the low pressure portion of the circuit it may be possible to close off the spigot. The spigot drains into the spring pocket of the valve which must itself be drained to prevent clearance flow oil from adding to the spring value.

Larger valves of this type are similar in operation with the exception of a hydraulic additive to the main spring as shown in Fig. 13. The main spring is relatively weak, usually equivalent to around 50 psi. Bleed oil from the secondary, or low pressure side, is introduced into the spring chamber at the top of the spool. A small pilot relief valve holds pressure in this spring chamber which is additive to the main spool spring value. Higher pressure oil passing over this small relief valve is then directed back to the reservoir. Rate of pilot flow is usually low.

Oil from the integral relief valve can be directed in series to another remote control valve so that the adjustment of the reducing valve can be effected at a remote point. In this particular application the control is just the opposite of the comparable relief valve series. The integral pilot relief section of the normal maximum pressure relief valve controls the maximum pressure, and the remote stations are in parallel and control the pressure to lesser values. In the case of the reducing valve pilots, the integral pilot relief segment controls the minimum setting and the pilots in series control to higher pressures. A program of varying pressure is possible with the pilot type reducing valve by directing the oil to various remote control pilots or by putting the desired number of control pilots in series and teeing off lines to tank through suitable directional control valving to establish the desired

degree of control.

A word of caution is in order when remote control stations are involved with a piloted reducing valve. If the integral pilot control is set at the desired minimum and secured with a lock wire and seal, it will only control MINIMUM pressures. The remote control device must be set to a desired maximum when connected in series. Special parallel remote control circuit models are available when necessary.

Installations that are critical to possible over-pressure conditions can be accommodated by tailoring the spool movement closely to the volume requirements. Insertion of shims under the main spool will reduce the opening between the high pressure inlet and the low pressure outlet to the minimum necessary for maximum flow conditions. Less pilot oil is required to move the spool to the closed position and reaction time is proportionally reduced. Where inherent shocks are expected, shimming valves is a common practice.

It is sometimes possible to setup the circuitry so that a return check is not necessary. In the average application of a reducing valve in a cylinder line where it is only desirable to reduce pressure in one direction, the return check provides a dependable method of getting the oil back past the valve with a minimum of resistance. If the pilot segment of the reducing valve can be drained into the opposite cylinder line it will act as a pressurizing line when the cylinder is reversed. Application of pressure to the drain on a piloted reducing valve prevents the spool from closing so that a return flow through the normal valve is possible without the use of an integral check valve.

However, this is not a dependable method when there are large area differentials between head and rod end of the cylinder. Excessive flows because of the differential operation or intensification factors may preclude the use of the drain into an opposite cylinder line and require the model with integral check valve.

Most piloted models are provided with an orifice between secondary line and control chamber that contains a small pin. This pin controls the rate of flow into the control chamber at the reduced pressure value. In certain circuits it is possible to increase efficiency and degree of control by varying this orifice. To change the orifice the diameter or length of pin is varied. Variation is rarely required but in the event the valve is to be used with fluids with either extremely high or low viscosity, a method of making the valve more compatible with the fluid media is readily available.

Special connections are sometimes made into the control chamber of pilot operated reducing valves to connect pressure switches so that they will register or operate on the pressure additive created by the integral pilot relief valve. The switch is protected to a degree by the fact that the oil must come through the orifice spigot, or pin, prior to acting upon the switch. The switch must be set at a value lower than the adjustment of the reducing valve or it will not function.

A pressure gage connected at this point will not provide an absolutely accurate reading, but it is protected both by orifice and integral relief. The gage will provide a relative reading which is often satisfactory. The life of the gage is lengthened by the absorption of surges in the orifice mechanism. The immediate response of the integral pilot relief protects the gage from over pressures due to shock. This is, of course, not true of excessive or prolonged shock conditions which most often indicate faulty circuit components.

In developing circuits containing one or more reducing valves, it is usually the practice to allocate approximately 80 to 100 cubic in./min of operating oil or fluid. Each valve in the circuit would be figured at this value. Normally the requirement is about 25 per cent of the figure stated above, but the larger quantity takes into consideration inherent circuit changes such as wear on the pumping medium and nuisance losses in other parts of the circuit.

When reducing valves are used from a central source of hydraulic pressure to actuate molding presses or similar devices, it is usually considered good practice to install a pilot operated check valve, or similar poppet type shut off valve, ahead of the reducing valve to block the line while the press is open during the loading cycle. Often the loading portion of the cycle is relatively long, and the poppet type pilot check valve avoids losses from the central system while this portion of the circuit is involved. Special pilot operated check valves can be provided with large piston areas operated from a low pressure pilot source to open a relatively high pressure line. Practically any type of pilot valve operating from the low pressure source can actuate the pilot check valve. Sometimes the pilot check is operated through the pilot valve upon receipt of an electrical signal from limit switches on the machine, or in some more complex circuits from an electric eye or air gap sensing device.

Automatic devices of the type mentioned above appear at first glance to be "gilding the lily," but a close analysis of production costs over a relatively short period of time will indicate savings that make the cost of the equipment involved seem negligible.

Actual wearing parts on a reducing valve are not normally critical and long service life can be expected. As long as the circuitry is compatible with the inherent operating requirements of the valve, few difficulties need be expected.

EDITOR'S NOTE:—Last month Mr. Pippenger gave detailed descriptions of *Relief Valves* of varying complexity. Starting with the simplest form of spool or poppet controlled by a spring the article covered piloted relief valves, stepped spools, electric control and typical applications.

In March 1957 the third of this series on *Flow Control Valves* will be published. These valves control and limit flow to and the speed of a hydraulic actuator.

Two additional articles are planned for spring and early summer publication dates. *Directional Valves* will include four-way valve spool design and typical circuit applications. *Valve Circuits* will cover the special configurations used in regenerative, tandem and high-low circuits.

Other articles published in *Product Engineering* this year demonstrating the use of control valves include:

"Hydraulic Control of Speed and Inertia," by Johnson and Bjorklund, Sept 1956, p 140.

"Functional Design of Hydraulic Systems," by Stewart and Moritz, July 1956, p 171.

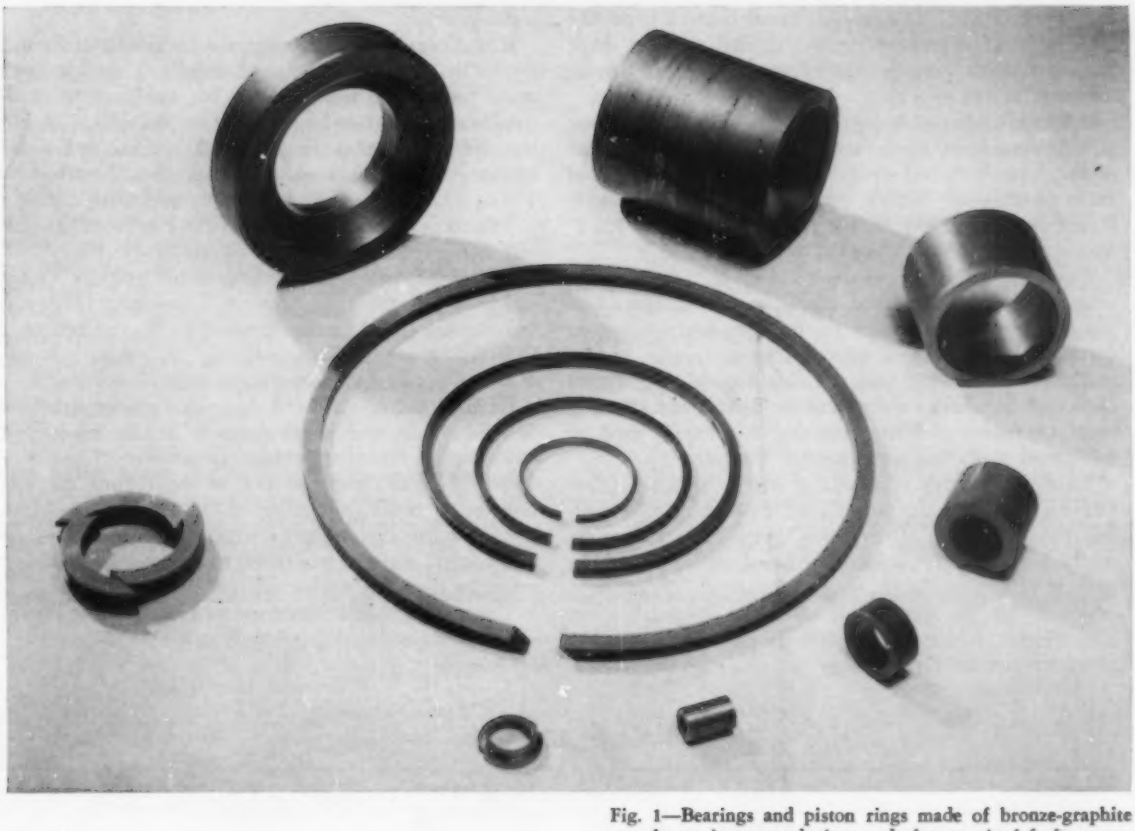


Fig. 1—Bearings and piston rings made of bronze-graphite are shown in assorted sizes and shapes. At left is a segmented shaft sealing element made of the same material.

A New Oil-Less Bearing Material

Characteristics and properties, advantages and limitations of full density graphite-metal powder combinations, self-lubricating even at extreme temperatures and pressures.

JOHN D. SHAW and WALTER V. KNOPP
S-K-C Research Associates, Paterson, N. J.

WHERE TEMPERATURE, pressure, speed or corrosive conditions make retention of a lubricant impossible, this new composition will provide a graphite film that cannot flow away, evaporate or become tacky. The material consists of graphite incorporated in matrices of metal powders at densities approximating those of wrought alloys.

Elimination of contamination of product, process or equipment by such lubricants as oil or grease is also possible. Graphite-metal mixtures have already been used where lubrication, after installation of the components involved, is difficult or impossible. Some typical applications are shown in Fig. 1.

Development of these graphite-metal powder mixtures began in Germany some eight years ago. The American supplier is Deva-Metal Corp., Ridgewood, N. J.

Graphite content may vary, depending on the application, from 6 to 25 per cent, by weight. This percentage is much greater when it is considered either on a surface or volume basis.

Uniform distribution of the graphite in the metal pow-

ders is important. The graphite-metal mixture is pressed into preforms approximating the desired finished shape and dimensions. Forging then follows, resulting in bearing materials of full density.

A variety of metal bases have been employed. These include bronze (with or without lead), brass, iron and nickel. Some typical operating conditions for each of these metal bases include: bronze, −300 F to 750 F; leaded bronze, −300 F to 400 F; brass, −300F to 400 F; iron, −300 F to 1250 F; nickel, −300 F to 750 F.

Since these bearing materials can be employed at relatively very high and very low temperatures, the standard testing procedures used for ordinary bearings proved inapplicable. However, with a Carson friction testing machine, it proved possible to obtain certain significant data, such as figures for wear and coefficients of friction, at room temperature. This equipment is normally used by fabricators of friction components.

Since the function of a bearing is essentially the opposite of a brake, this test proved readily adaptable to evaluating the properties of the new graphite-metal powder mixtures. Test data obtained are based on samples of the new materials produced in this country. Tests were primarily for the purpose of obtaining information on the effects of varying graphite content and on the characteristics of the matrices provided by the various metal powders.

It was possible to determine the coefficient of friction, rise in temperature, and loss in weight of the specimens under test. Each test specimen was machined to fit the outside cylindrical surface of a 14 in. dia drum. A hole was drilled in the specimen ¼ in. below the test surface for temperature checking, by means of a thermocouple. The specimens were weighed before and after testing.

The effect of varying graphite content in bronze-graphite and iron-graphite mixtures is shown in the table. The radial crushing strength decreases as the graphite content increases. As the graphite content increases, the weight loss decreases with some decrease in the coefficient of friction. A photomicrograph, Fig. 2, shows a typical distribution of graphite in a metal matrix.

Detailed testing has been done on these materials not only in varying the combinations of metals and graphite contents, but also at elevated temperatures. It was found that a problem developed not in the bearing combinations being tested, but rather in the construction of the test rig and in the surface on which the new material ran. The contact material was found to be more susceptible to oxidation than the bearing mixture itself.

The metal-graphite combinations are not to be thought of as a panacea for all bearing ills. Rather, they must be considered as specialized materials for use where high or

Effect of Varying Graphite Content

Graphite, pct	Radial Crushing Strength, psi	Friction Tests				
		Surface Speed, fpm	P-V Factor	Temperature, F	Coefficient of Friction	Weight Loss, pct/hr
BRONZE-BASE MATERIALS						
8	45,400	1130	56,500	125	0.2754	0.062
			113,000	195	0.2615	0.917
			169,500	232	0.2472	1.174
			226,000	225	0.2352	10.834
10	33,700	1130	56,500	163	0.4237	0.059
			113,000	190	0.2719	0.784
			169,500	213	0.2197	0.952
			226,000	232	0.2250	1.028
12	28,700	1130	56,500	127	0.2331	0.090
			113,000	190	0.2510	0.728
			226,000	207	0.1534	0.997
			339,000	220	0.1093	1.218
15	14,800	1130	56,500	133	0.2542	0.059
			113,000	210	0.3033	0.608
			169,500	210	0.2197	0.743
			226,000	210	0.1483	0.734
			339,000	220	0.0528	0.878
IRON-BASE MATERIALS						
6	51,000	427	21,400	110	0.2542	0.263
			42,700	Excessive Wear		
8	29,600	427	21,400	112	0.2754	0.218
			42,700	160	0.2929	0.384
			64,000	Excessive Wear		
12	16,200	427	21,400	120	0.3390	0.051
			42,700	143	0.2615	0.162
			64,000	162	0.2335	0.552
			85,400	185	0.2301	0.736
			128,000	222	0.1410	1.797

Background of Metal Powder and Graphite in Bearings

The best-known application of metal powders to bearings is, of course, sintered oil-less or oil-containing porous bearings. This bearing is usually made by pressing a blend of 90 copper—10 tin powders with a volatile lubricant and with or without small percentages (up to 2 per cent) of graphite. The part is compacted to 70-80 per cent of theoretical density, sintered and sized (repressed) to final dimensions. The finished bearing, which contains approximately 20 per cent voids, is impregnated with oil, and its sponge or wick-like structure acts as an oil reservoir throughout the life of the part, provided it is not subject to high speeds or loads, or excessive temperatures. This type of bearing has found universal acceptance, and exhibits excellent properties in service.

Originally, sintered porous bearings were made with high graphite contents (up to 6 per cent). Unfortunately, by the very nature of the method of fabrication, the strength of such bearings decreases with increase in graphite content. This is why conventional porous bronze bearings contain little graphite.

It has been known for a long time that certain types of graphite possess excellent lubricating properties. Yet, normally, solid graphite has poor strength even when bonded with carbon bonding agents. The use of finely divided graphite in conventional bearings has always posed a problem of how to secure a uniform layer or film on the surface of bearing and bearing surface, and if it is in powder form, how to keep it there.

The high-graphite, porous, sintered bearing is not satisfactory, due to its basic weakness even at relatively low graphite contents. The addition of greases and oils to graphite powder is only a compromise at best, since if temperature becomes too high, the grease or oil will dry out and evaporate, and the graphite powder will blow away.

The problem, therefore, becomes one of incorporating graphite in a metal matrix of sufficient strength, which would have requisite bearing characteristics and still develop and retain a film of graphite under a wide range of temperatures, loads, speeds, and corrosive conditions, such as presented by water, steam, and the like. A bearing material developed to meet these conditions is described in the accompanying article.

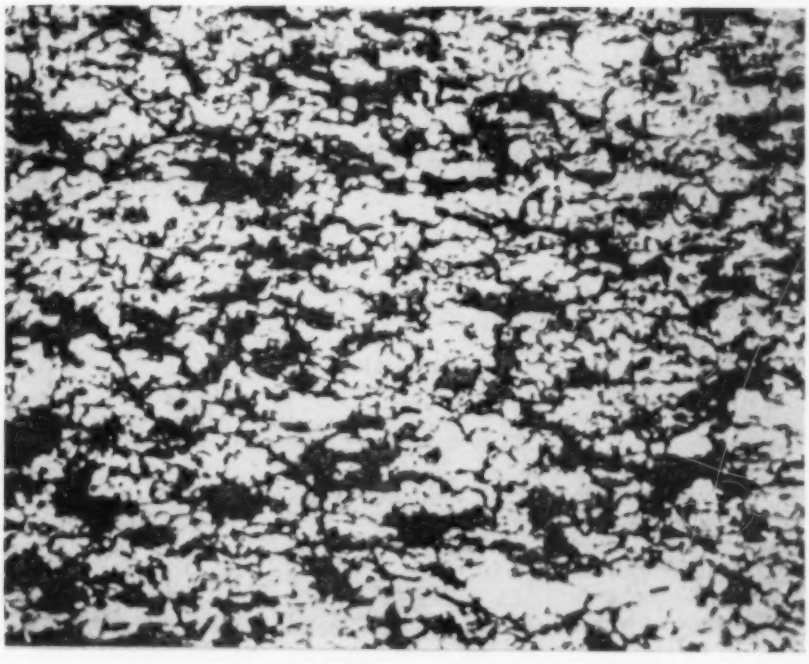


Fig. 2—Typical distribution of graphite in metal powder matrix, after hot pressing to full density. Magnification, 500X.

low temperatures or the danger of oil contamination would cause conventional bearings to fail or prove inadequate.

There are certain limitations. Among them is the necessity of using metal powders and graphite which must be specially prepared. Forming techniques are slower and more costly—for example these graphite-metal powder mixtures cannot be fabricated by the same techniques employed in producing ordinary sintered metal powder bushings.

There are also a number of advantages in addition to those cited previously. These include: a) good running properties with negligible abrasion to give excellent long-time life; b) minimum of starting difficulties, since the bearing produces an adhering graphite film which will not flow away; c) good corrosion resistance, since a wide variety of metal powders can be used and the proper alloy can be selected to meet the required application (the graphite is in sufficient quantity to add corrosion resistance to the metal); d) large range of temperatures and pressures can be employed; e) corrosion of sliding parts is negligible; f) use of oil is eliminated, resulting in complete dry running with absence of oil evaporation and contamination (can be used with certain oils and greases); g) freedom in positioning bearing since graphite will not flow away.

Reducing Trial and Error in

Compression Spring Design

J. J. INTINTOLO
Project Engineer Aviation Division C. D. C. Control Services, Inc.

Graphical method sets up a boundary of acceptable spring dimensions based on variables of spring design. Choice of wire diameter and outside diameter can be visually within this boundary.

USUALLY SPRINGS ARE DESIGNED by using equations in a trial and error process to determine wire diameter, mean diameter, number of coils and safe stresses for the material being used. Even with the aid of a spring slide-rule this procedure is extremely laborious. After achieving a design which reasonably satisfies fixed specifications it is still possible that a better spring could be designed with greater savings in weight or space or economy.

The problem is still more difficult if the design must be confined within definite boundaries such as a maximum diameter, minimum inside diameter, maximum and minimum working lengths, and maximum solid length. After trying many different combinations of mean diameters and wire diameters without being able successfully to satisfy design restrictions it may be assumed, wrongly, that the spring cannot be designed.

The following time-saving technique will virtually eliminate tedious trial and error methods as well as uncertainty concerning maximum economic and optimum design. It shows graphically whether or not a spring can be designed for a particular application. It also determines only those combinations that will meet the design requirements.

Example. An existing valve is to be adapted to a new application by changing the spring. Physical and functional requirements as illustrated in Fig. 1 are:

1. Maximum working load length, L_m = 0.73 in.
2. Minimum working load length, L_o = 0.89 in.
3. Minimum working load, P = 10.8 lb.
4. Solid length L_s must be safely less than maximum working load length, or less than 0.67 in.
5. Maximum outside diameter D_o = 0.34 in.
6. Spring rate to be as low as design limits will allow.

NOTE: A spring slide-rule is recommended at this point. It is not essential but saves much time as it solves the equations:

$$S = \frac{2.55PD}{d^3} \quad (1)$$

$$R = \frac{P}{F} = \frac{Gd^4}{8D^3N} \quad (2)$$

where

D_o = outside diameter
D = mean diameter
d = wire diameter
F = deflection
G = torsional modulus = 11.5 x 10^6 for music wire
P = load in lb.
R = spring "rate"
S = torsional stress in lb. per sq. in.

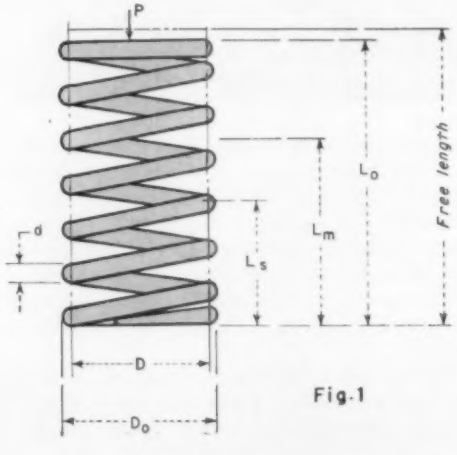


Fig. 1

Effect of Spring Rate on Boundary Curve

If there is no area available then by increasing spring rate both solid length and stress curves move to the right. The solid length curve, however, moves faster thus decreasing the distance between the two. This continues until an area is available for design unless the spring rate becomes too high. Then the large increment of load caused by the travel raises the stress so as to cause stress curve to move to the right faster than the solid length curve. Actually, in the example, used, a lower rate of 5lb/in. was tried in conjunction with stainless steel wire. This trial eliminated all design area as the stress curve was far to the right of solid length. Hence, a spring could not be designed with stainless steel wire and music wire was used. (Stainless steel was more desirable because it needs no proticetive coating.)

A few trials of low spring rates were made using music wire and increasing the spring rate each time until the final graph sheet shown in Fig. 4 was obtained. Such trials, depending upon what variables are available, are the only remaining elements of trial and error in a spring design using this method.

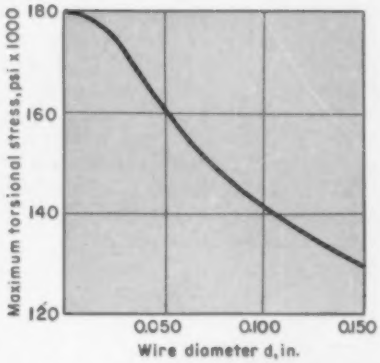


Fig. 2—Maximum torsional stress in music wire as influenced by wire size.

PROCEDURE:

1. **Lay out on graph paper** the mean diameter D as ordinate and wire diameter d as absissa. Choose suitable value of d so that the D_o plot of points falls relatively near top of graph. Plot D_o curve, $(0.340 - d)$ against D. An approximate value of d can usually be found by assuming a value of about 7 for the D_o/d ratio.

All area above this curve is eliminated for design purposes because the outside diameter will be too large.

2. **Choose a low spring rate**, e.g., 30 lb per in. Material is music wire. (See Box.)

3. **Use spring slide-rule;** set a certain number of coils under chosen spring rate on slide-rule. Plot D vs d curve from scale of slide-rule.

4. **Plot a family of curves** across graph by changing number of coils.

5. **Plot solid length curve** by finding maximum wire diameter allowable for any particular number of coils by adding 2 (for inactive coils) to that number of active coils, and divide result into maximum allowable solid length. Where this d crosses that particular coil curve will be found one point on the solid length curve. A similar point found for each coil curve thus defines the solid length curve. All area right of this curve is eliminated for design purposes because solid length would be too long. Final spring design must now be assumed to be in upper right corner of remaining area.

6. **Plot stress curve** using Fig. 2 to find maximum allowable stress for that particular wire diameter (say 0.048 in.) at upper right-hand portion of remaining area on graph. Divide by corresponding Wahl factor. Find approximate maximum load by using maximum allowable solid length (say 0.660 in.) to determine total deflection, e.g., (0.890 − 0.660) (30) + 10.8 = 17.7 lb. Set this load under maximum allowable stress. Plot curve of D vs d from scale of spring slide-rule. All area to left of this curve is eliminated for design purposes because spring would be overstressed.

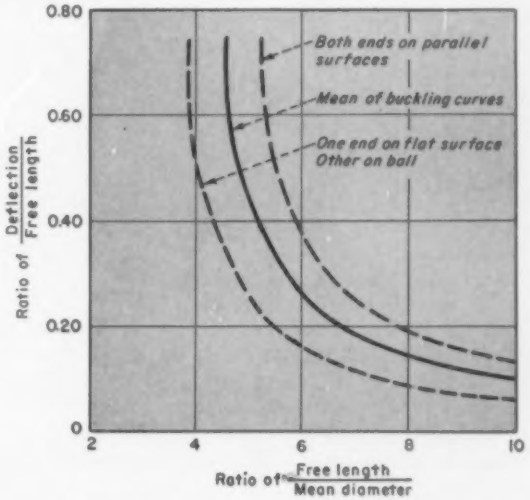


Fig. 3—Buckling occurs if deflection is greater than values shown. Curves are from Associated Spring Corporation design handbook.

7. **Buckling curve.** Calculate free length (based on solid length of 0.660 in., rate, and maximum load as found above). From Fig. 3 (mean curve used in this example) find allowable mean diameter. This is a horizontal line on the graph. All area below this line is eliminated for design purposes because of buckling.

8. **Remaining area defines the only combinations that**

can be used for design and even this is with reservations. As choice of spring approaches stress curve the solid length decreases. The total deflection and load is thereby increased. This moves stress curve further to the right. It is, therefore, safer to choose a spring on the right side of remaining area.

In this particular design Fig. 4 shows that the band of area available for design is only 0.005 in. for wire diameter and 0.034 in. for mean diameter. An analysis of this procedure actually leaves a smaller area available. If the design is close to the functional limitations (stress and buckling curves) these curves begin to converge, thus leaving a smaller area because, as explained above, these curves were obtained by assuming the design to be in upper right-hand corner of the area. The design may be chosen close to the D_o and solid length curve because these curves are physical limitations. They will not change and a safe tolerance was chosen in obtaining these curves.

9. **A spring can now be chosen.** There are only three standard diameters of music wire included in this area—0.045 in., 0.047 in. and 0.049 in. The 0.045 in. diameter cuts the lower left corner and is too close to the functional limitations to be a safe design. The 0.047 in. diameter is relatively in the middle of the area and is a possibility. But a design with this diameter would probably be critical in stress and/or buckling and would be used only if a better design was not available. The upper right-hand corner is barely cut by the 0.049 in. diameter wire and the spring can be chosen here without hesitation.

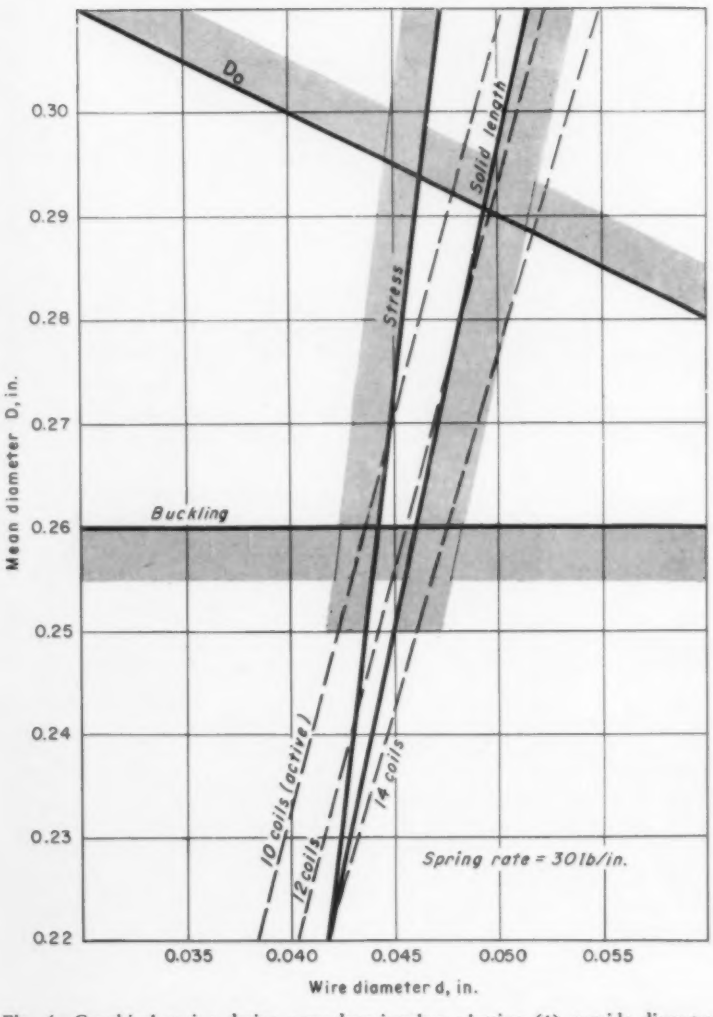


Fig. 4—Graphical spring design procedure involves plotting (1) outside diameter curve, (2) D_o vs d for various numbers of coils, (3) solid length curve, (4) stress curve, (5) buckling curve. Spring is chosen from top right side of area bounded by curve.

New Uses of Ultrasonics

INCREASED CHEMICAL ACTIVITY of metals subjected to the action of ultrasonics is believed due to decreased cohesion of the crystalline structure of the metal. One application of this particular phenomenon has been in the nitriding of steels, normally carried out at about 500 C in an ammonia-rich atmosphere. Standard nitriding procedures produce a hard case, which is very shallow, reaching a depth of one millimeter after 48 hours at 550 C. The use of ultrasonics in the course of the nitriding process greatly increases the depth of penetration of the nitrogen, cutting cycle time and permitting the use of lower temperatures.

Investigations have been carried out which show that ultrasonics have a marked influence on the magnetic and electrical properties of metals also. This, too, is ascribed to a reduction of cohesion of the crystalline structure. Experiments on nickel indicate that magnetization increases as the intensity of the applied utrasonics, and this magnetization remains even after application of the ultrasonic wave has ceased.

Some metals can be made to go through allotropic transformations by the application of ultrasonics. Tin may be made to pass from the white to the gray state and vice versa by the application of waves of the order of 750,000 cps and by varying the ambient temperature between −20 and 12 C.

Abstract from "Les applications des ultrasons en métallurgie et en mécanique" by P. Hemardinquer in *Revue Générale de Mécanique*, Paris (France), Sept. 1956.

Tape Controlled Machining in Small Lots

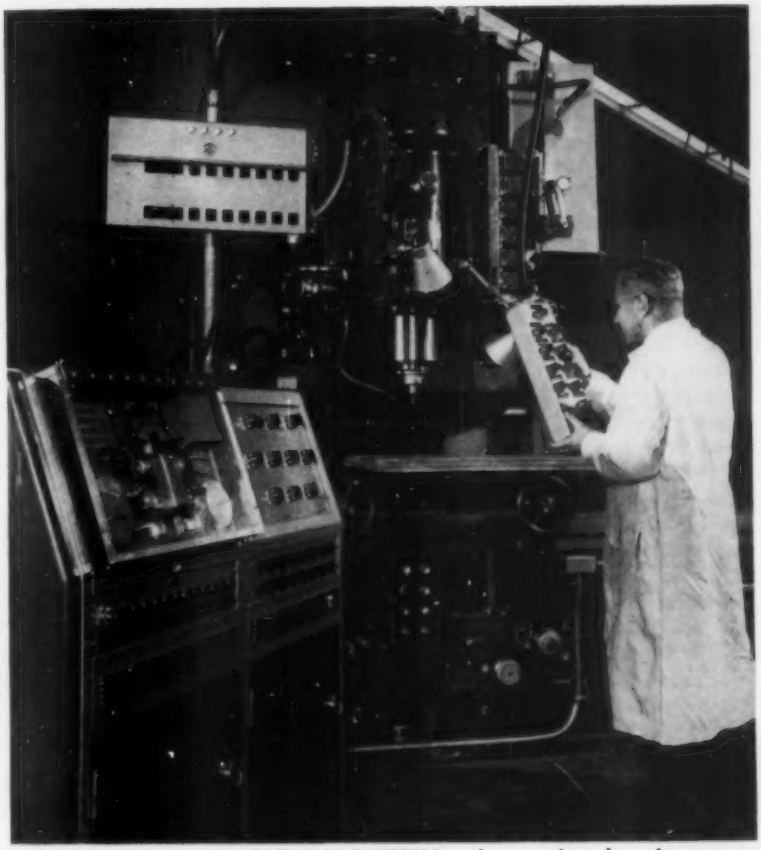
Automatic machining, whose advantages were limited to high-volume production operations, have been extended to small-lot and single-part production of aircraft tools and parts at North American Aviation, Inc., Los Angeles 45, Calif. Numill, the name of the new tape-control system, can be used to automate many of the standard machine tools, such as lathes, boring mills, contouring mills and grinders.

The controls were developed by North American's Autonetics Div., specifically to produce templates, profile bars, profile mill fixtures, and other two-dimensionally parts used in aircraft manufacturing. A standard milling machine controlled by the tape system automatically performs the hole-drilling, scribbing, and contour-milling operations.

Procedures presently used for template-making require that the master contour lines be laid out on metal loft boards by loftsmen, using previously developed coordinates. These master lines are duplicated on template material by an expensive contact-printing process, and the desired line is filed to shape by a template maker.

With numerical control, starting with point coordinates, formulas, or other numerical definitions of the template or tool contour, a machine control tape is produced, using digital computer techniques. The controls consist of a display panel, a control pendant, measuring gages and a tape reader control. The present Numill controls are applied to a standard 28 x 96 in. Cincinnati vertical hydrotel milling machine.

The display panel is used solely to inform the machine operator of the necessary set-up information, such as size and type of material, cutters to use, and machine speed. This data is received from the tape.



PRESSING THE "SLOW VERTICAL" BUTTON on the control pendant, the operator is about to start a template milling operation which is tape controlled. Developed by the Autonetics Div., of North American Aviation, Inc., the Numill control system, as it is called, will offer the advantages of automatic machining to small-low and single-part production. At upper left is the display panel which gives the necessary set-up information. At left is the tap-reader console which reads the digital information from the control tapes, and translates these numbers into pulse-trains which control the machine-tool movements.

Measuring gages are on the back of the machine table and the slide of the machine column. Their operation is based on the use of interference patterns generated from optical gratings. Absolute accuracy is better than 0.001 in. over 8 ft at 68 F.

The tape-reader console—fully transistorized—reads the digital information from the control tapes.

Operation of the Numill. To make a template which requires drilling, scribbing and milling, the operator sets the dials on the console to the desired part. The tape reader searches and finds the required portion of the tape and gives instructions on the display panel as to proper material and cutting tool. The machine automatically drills a series of holes, and if more drilling is required, the display panel will indicate the drill size and rpm to be used, and when the set-up changes are made, automatically drills the required holes.

The scribing and milling operations are handled the same way. When the necessary changes in spindle speed and cutter type have been made by the operator, the machine performs the operations automatically. Left-hand and right-hand parts can be produced from the same control tape by turning an axis-rotate switch on

the tape reader console. The Numill machine will mill any contour desired at speeds up to 25 in. per min, although it is capable of controlling machine movements at speeds up to 200-300 in. per minute.

In drilling operations the machine moves from one point to another at 120 in. per min. After positioning, it follows a controlled rate of down feed. Combining milling and drilling in one set-up adds to the efficiency of the system. The efficiency is improved by the display panel which results in an effective working relationship between the man and the machine.

Numill's tape-making techniques are aimed at producing control tapes as cheaply as possible, using available planning and clerical skills. The operation begins with the engineering drawings. Input data to the computer is held to a minimum and consists of: basic tool or part dimensions; sequence and type of operations; machine spindle speeds and cutter sizes (feed rates are calculated automatically); type and size of material. All the necessary information to make a template or part of average complexity is on about 12 in. of tape.

The computer calculates the path which must be followed by the center of the cutter to make the contours that are specified. This path consists of a series of straight line cuts, which approximate any curve to a given tolerance.

Machine movements are translated into pulses, each of which represents 0.0005 in. of movement. The pulse trains generated from tape commands are continuously compared with the pulse trains generated by the optical gaging system.

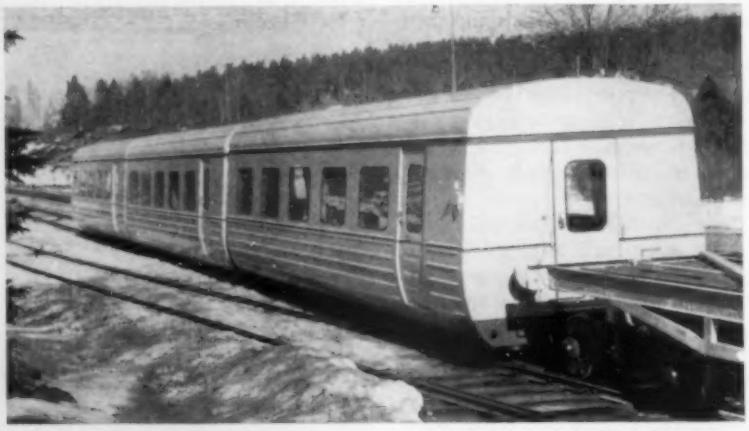
Smaller Memory Devices

Electronic computers will be able to store more than a million bits of information in a space just a little larger than a shoe box, and to recall any or all of the items in a few millionths of a second with a new memory device developed by the David Sarnoff Research Center of the Radio Corp. of America, Princeton, N. J. The new memory consists basically of thin, printed plates of special magnetic material perforated with small holes.

The new aperture plate memory stores the information in the form of magnetic fields. One of the two values is represented by a flow of magnetic flux in one direction around a hole in the plate, while the other value is represented by a magnetic flux in the opposite direction. The small plates are made of a ceramic-like ferromagnetic material that can be molded in any size or shape. The plates are less than one inch square and contain 256 holes, or a storage of 256 bits of information.

The plates themselves are insulators, and the holes can be joined by conductors using the printed circuit technique in place of the storage and readout windings of the previous core system.

Besides memories of very large capacities, the new system makes possible compact memories of relatively small capacity. In this respect, RCA has a developmental unit measuring only 2 cu in. which has a storage capacity of 2560 bits of information.



PASSENGER CAR LENGTH and shape closely resemble that of the U. S. Talgo type train announced several years ago. Pulled by a lightweight and low-power engine, the train can reach a speed of 94 mph. A motor generator supplying 380/220 v, 3 phase a-c at 50 cps is used, with electrical power for the motors and lighting taken from it. The locomotive has a drive on all four axles.

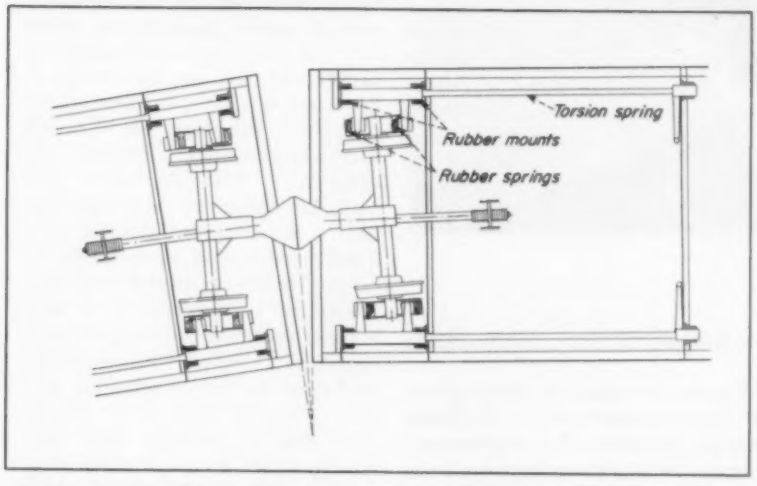
Sweden Designs Low, Lightweight Train

Railroad companies all over the world are feeling the effects of the competition with other forms of transportation. In Sweden the main competition is the automobile. The number of railway passengers has fallen, particularly on short distance runs, while long distance traffic is the economic backbone of the passenger traffic. Efforts are being directed towards strengthening this backbone.

Like the U.S., Sweden is turning to the low slung, lightweight train to attract passengers to railways. Cars of the KLL train are shown above. Meaning short, low and light (kort, lag and lätt), the Swedish design, however, has avoided the disadvantages of the earlier low, lightweight trains, some of which can be driven in only one direction, (Spanish Talgo) and others which are fixed-length trains (U.S. Talgo).

The KLL consists of individual cars which are coupled together by an automatic central coupling. Each car has two axles, and each can be added to or withdrawn from the train at will, and can be run in both directions. This is unlike the Spanish Talgo principle where the back end of one car supports the front end of the car following it. As the KLL car is a separate unit, it is possible to build up trains of any size and composition.

Floor height above the rail top of the KLL is 22 in. This compares with 18 in. for the original Spanish Talgo, and 26 in. for ACF Industries' American Talgo (see *Product Engineering*,



DESIGN OF UNUSUAL TYPE coupling and running gear, which steers the wheels around the corners. This is necessary because of the risk of riding-up and derailing on curves. The brake is of the single-action disk type with the disk mounted on the inner side of the wheel (see photo). When the brake is applied, two brake blocks, one on each side of the supporting axle, are pressed against the disk. Each brake block has its own brake cylinder. The car is sprung with rubber and torsion springs (see line drawing). Two high rubber springs rest on a yoke mounted outside the wheels. In addition to their springing function, the rubber springs absorb the deflections of the wheels when taking curves and the lateral movements of the body with respect to the running gear. The two "fingers" resting on top of the springs, extend out, and are attached to the torsion spring running in the direction of car's axis.

p 194, July 1955). Floor height of conventional car is 4 ft, 4 in. Center of gravity of the KLL is about 41 in. compared to 40 in. for the Spanish Talgo and 42 in. for the U.S. Talgo. Length of the KLL car is about 37 ft; the Spanish Talgo 18 feet. The U.S. Talgo car is 36 ft long, but its design requires the cars to be used only in units of three. The conventional Swedish car length is 76 ft.

The car framework is of steel and is spot welded throughout. The company, A. B. Svenska Järnvägsverkstäderna, Linköping, Sweden, estimates that the superstructure would have been 500 lb heavier if arc welded.

The unique aspect of the lightweight train is the running gear, which steers the wheels to keep them tangent to the track at all times. The wheels then follow the curve without hunting or jerking motions. The axles are built integral with the central coupling which is attached to them by a longitudinal central tube. When two cars are coupled together, and the central couplings with which they are connected fit closely together, the two sets of running gear connects in this way from a bogie.

Each end of the car rests on its running gear on rubber blocks outside the wheels, and the arrangement is such that each pair of running gears forming a bogie, automatically adjusts itself to the curve and gives the car a steady motion. The tensile and compressive stresses between the car are taken up by a bar, one end of which is centrally attached to the rear of the central coupling, while the other end is fixed to the chassis of the carriage someway inside the running gear. In this way, the running gear itself is relieved of tensile and compressive stresses. The locomotive is coupled in similar fashion to the leading running gear of the first car.

Tin Cans Act As Radiator

Tin cans will play a prominent part in testing the models of the latest supersonic jet planes and guided missiles. More than eight million new cans have been dumped into the air-storage section of North American Aviation's new $5-million Trisonic wind tunnel being built at the International Airport in Los Angeles, California.

The cans will fill eight steel spheres, 36 ft. in diameter, where 200,000 cu. ft. of compressed air is stored for use in the tunnel. The cans will act as a radiator, keeping the air temperature nearly constant during a test blow. Without the cans, the air temperature would drop about 200F during a test blow, causing errors in test data. The cans reduce the sudden temperature drop to a workable 30 degrees. A heater which could supply enough warmth to the air during the short period of a test blow would have been too expensive to build and operate. The cans are all new rejects supplied to North American by various container manufacturers.

The largest privately owned wind tunnel in the U. S., it is capable of speeds up to 2500 mph. It will be completed this month, and will provide research in a single tunnel in three areas: subsonic (less than the speed of sound); transonic (through the speed of sound); and supersonic (above the speed of sound).

New Filming Process for Handling and Filing Drawings

The person in the photo above is holding in his right hand a 105 mm negative of the engineering drawing beneath it. From this 4 x 6 in. negative, the drawing can be blown up to any size, all the way up to a 36 x 54 in. reproduction, without distortion. One negative can hold up to eight 8½ x 11 in. drawings.

Done by the Micro-Master 105 mm process, it is a new reproduction service offered by Keuffel & Esser Co., drafting materials and equipment manufacturer, Adams & Third St., Hoboken, N. J. A company retaining this service will send its drawings to one of the Micro-Master service centers about the country where they will be reduced to the 4 x 6 in. negatives that the company will keep in its file. Duplicates of each negative are made so that the company can keep a second file to insure against loss. A 6 x 9 x 12 in. file box will hold 450 negatives.

To get a reproduction of this drawing, the negative is mailed to the service center where it is blown up to any size, up to 36 x 54 in., to make a "Second Original." From this, working prints are made on opaque paper or cloth by the Blueprint or Diazo process. Or, the 4 x 6 in. master negative can be used to make a 4 x 6 in. card print which is used in a table viewer with an 8 x 12 in. viewing surface. By the same token, the negative can be projected on a large screen for conferences. By joining the large 36 x 54 in. prints together, an unusually large drawing can be reproduced in whole or in part. Also, photographically, the drawing scale can be accurately changed.

K & E claims that the Micro-Master prints are at least as good as the original tracings in every case, and frequently are better than the drawing itself. The weakest line on the oldest drawing is picked without respect to any background dirt. The negatives do not require any corrective opaqueing, nor artwork, except to eliminate undesirable parts of the drawing. This, plus the easy filing; convenience of "reading" on sight, plus enlargements without distortion are the reasons 105 mm was picked over the smaller micro-filming processes.

Forming Titanium At High and Room Temperatures

Titanium sheet can be formed at room and high temperatures . . . . on conventional equipment, according to Boeing Airplane Co., Seattle, Washington. It was observed that at room temperature, 6 Al-4V titanium can be formed in a curve having a radius six times the thickness of the material, permitting sheet-roll forming, and stretch forming of sheets and sections. Above 800 F, the same alloy can be formed in a curve having a radius three times the material thickness. Generally speaking, any shape that can be formed in conventional aircraft materials can be formed in the titanium alloy with conventional equipment, if the blank can be heated and maintained at a sufficiently high temperature. Integrally heated tool steel dies, protected from corrosion with a flame sprayed Ni-Cr-B powdered metal coating now are used on existing brake equipment and show promise of being adaptable to drop-hammer operation. In brake forming experiments under manufacturing conditions, one punch protected with such a coating showed no damage from wear or corrosion after three heat-up cycles to temperatures ranging from 900 to 1400 F for more than 18 hours.

Ceramic lubricants developed by Boeing are used for high temperature forming between 800 and 1500 F. Colloidal graphite is practical up to 1300 F. Ceramic lubricants for forming temperatures above 1800 F depend upon two factors, the control of tool temperature and material temperature within a range of 100 F.

For heating the titanium and the forming tools, electric heat was found to be most advantageous for heating blank sheet material for press brake and hammer forming, while induction heat shows far more promise for heating moving strip for draw bench and multi-stage roll-forming of structural sections. Electric tubular cartridge-type heaters are easily adaptable to integral heating of punches and dies for non-impact forming, but a premixed gas is preferred for heating the majority larger tools and tools subject to impact.

Briefs

Research on new soft solders of improved performance is reported to have led to the development of a number of new tin-lead solders which have unusually long life at temperatures of about 223 F. Developed by the Battelle Memorial Institute in London for the Tin Research Institute, the performance of these high-tin content solders at high temperature can be improved by the addition of small quantities of germanium, nickel or cerium. Additions of small amounts of zinc, bismuth and antimony is also claimed to be beneficial. Potential use of the new solders is for soldering car radiators where operating pressures of 16 psi are used.

The ninth annual report of the Advisory Council on Scientific Policy just published in London urges that the Western countries keep track of what Russian technicians are doing. To do this, the report stresses the importance of reading Russian. The technical lending library services cannot handle the increasing output of Russian scientific and technical literature. There are at least 1000 current periodicals in this category, and more than 14,000 scientific and technical books were published in Russia in 1954, against which even the British Museum in London takes only about 800 a year; the Dept. of Scientific and Industrial Research, 300; while 170 other libraries get about 1000 between them. Of the translation problem, only 2 per cent of British working scientists read Russian, compared to 80 to 90 per cent who read French, and 60 per cent who read German.

Argonne National Laboratory has just placed in operation an unusual type of reactor known as a "slow-fast" reactor. No producer of electrical power, it will be used for studies of future large power reactors. The new ZPR-V is, in effect, a reactor within a reactor. The entire unit consists of a 5 ft dia steel tank in which the uranium fuel assemblies and the control rods are placed. In the center of this tank is the "fast" reactor section containing 49 enriched uranium fuel assemblies which are placed in a soft square section. Surrounding the "fast" reactor section is the "slow" reactor section which consists of normal and enriched uranium fuel elements arranged in a geometric pattern around the "fast" core section and immersed in water. The nuclear chain reaction takes place in both regions although they have entirely different nuclear properties. By connecting the two systems together, it becomes possible to study the nuclear physics of "fast" reactors without having the good control of the "slow" reactor.

New processes for manufacturing metal boride ceramics containing titanium, columbium, thorium, and a number of other metals have been patented in England. In the case of titanium boride, titanium hydride and boron powder are first pressed into briquettes and then heated in a hydrogen atmosphere at temperatures ranging from 1800 to 3600 F. During this heat treatment the titanium metal and the boron combine to yield a boron hydride. The material is reported to be very hard, and has a melting point above 5400 F. Borides of zirconium, thorium, and tantalum can be prepared in the same manner.

Plastic molding presses made by F. J. Stokes Corp., Philadelphia 20, Pa., now have a rope-feeding attachment which makes it possible to mold automatically the glass fiber reinforced polyester resins which are currently being supplied in extruded "rope" form. With glass fiber reinforcement, the impact strength of the polyester materials is improved, and with the automatic molding attachment, the applications for these resins is increased. The attachment can feed up to 24 cavities, located over the whole area of the platen, in almost any arrangement pattern. The attachment can be used with different molds. The rope-feeder will accommodate various diameters of rope.

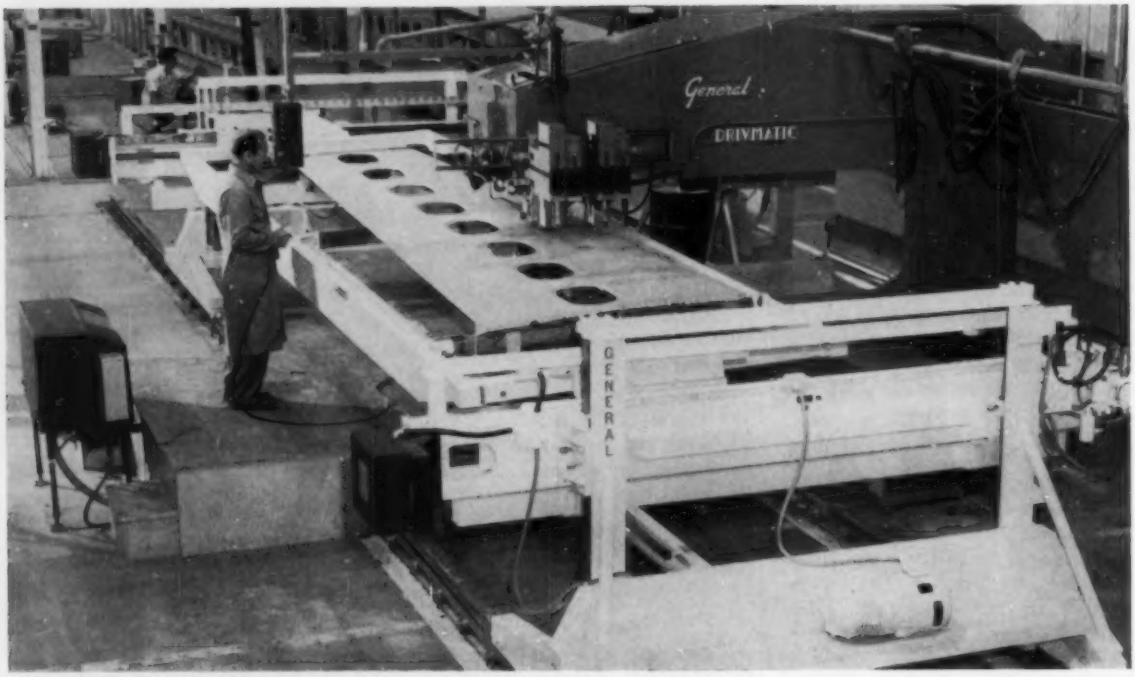
Industry Intensifies Ph.D Recruitment

Industry is branching out in its constant search for more engineers. It always has been open season on the new B.S. graduates, but recent figures from Carnegie Techs Placement Bureau indicates a marked trend on the part of industry into the Ph.D field. This drive is accompanied by a significant increase in the number of students taking graduate work.

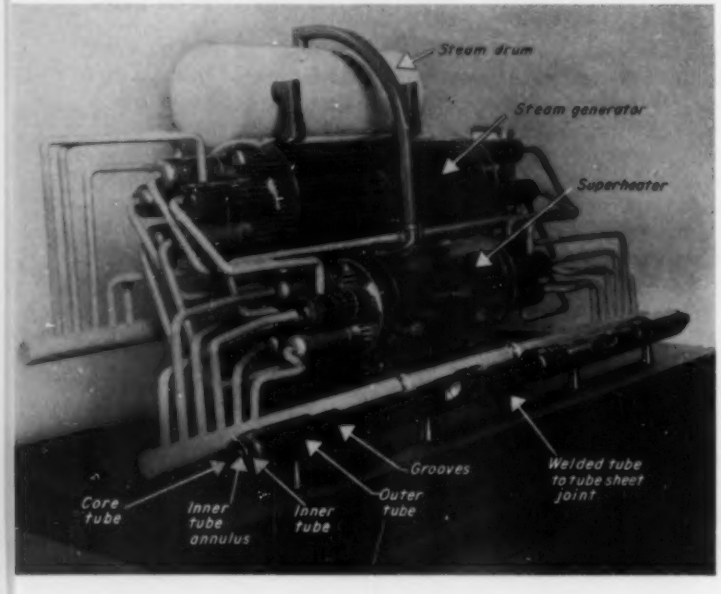
In 1955 at Carnegie Tech, only 40 companies sent interviewers to the campus to recruit graduate students. As of the latter part of 1956, more than 70 major companies have made arrangements for interviews. Since the interviewer for graduate students is quite different than for B.S. students, companies this year will be making two trips to the campus. Because of the advanced education of the Ph.D candidate, the company recruiter is a technical man, such as research directors. For B.S. graduates, the recruiters usually are from the personnel department. (This latter approach to B.S. graduates is wrong, according to Chester Linksy, Asst. Prof. of Industrial Engineering, Pennsylvania State University, see Perspectives, July 1956, p 129. Mr. Linsky claims that such personnel representatives cannot answer specific questions about the company's engineering department operation. Mr. Linsky cited one instance where a recreation director from a company arrived on campus to recruit engineers.)

The interviewing of Ph.D candidates will not be limited to those expecting to get their degrees in June. Recruiters are scouting as much as 20 years ahead. According to Joseph W. Ludeqig, Assit. Dean of Graduate Studies and Asst. Hd. Metallurgical Engineering, "There are three reasons for this trend towards advanced in the Metallurgical Engineering Dept.: (1) the increase of fellowships granted from sponsoring private corporation enterprises; (2) the recent move to grant a metallurgical engineering fellowship at Carnegie Tech in the first year of graduate work, something not done before; and (3) the steady and continuing efforts of two professional societies, ASM, and the American Institute of Mining and Metallurgical Engineers.

THE NEWS IN PICTURES

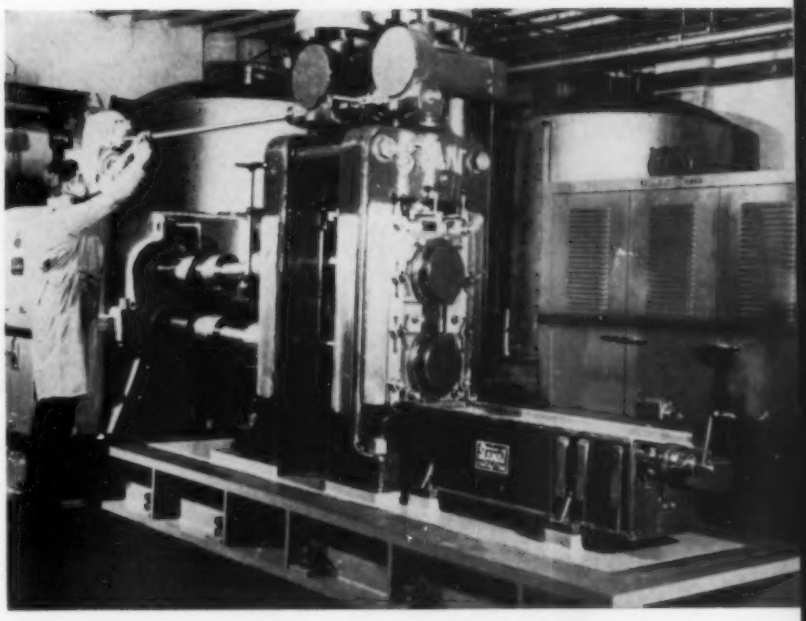


PRODUCTION OF the 20 ft long fuel sealed wing segments at Northrop Aircraft, Inc., has been increased 400 per cent with this automatic riveter which drives fuel sealed slug rivets at the rate of 7 rivets per minute without using soft metal sleeves or fuel sealant compounds. The Drivmatic riveter shown here was manufactured by General Riveters, Inc., Buffalo, N. Y. A tape controlled machine, three tapes control the positioning and cycling requirements. The drilling head drills, reams, countersinksg, and counterbores in one pass with one tool. Rivets are driven from the bottom, and are shaved flush with the skin. No feather edge is left by the shaver due to the slight counterbore (0.010 in.) made in the countersink. The curved part is kept horizontal at the drilling and riveting heads by twin cams which elevate and tilt the part to the proper attitude as the carriage travels. Two men can set up the machine, and one operator makes four parts in the time formerly required to make one.



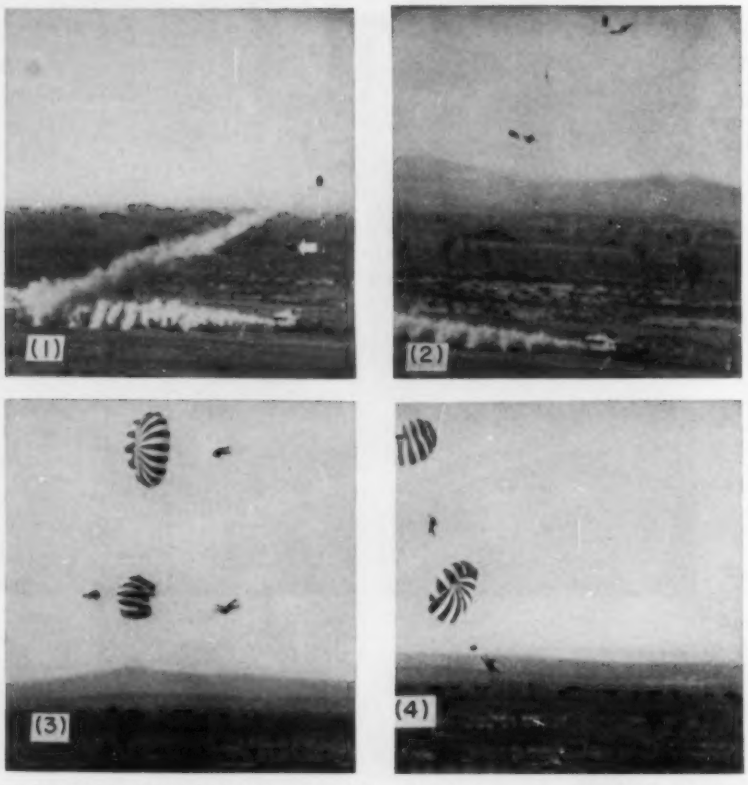
AN UNUSUAL FEATURE OF a liquid metal heated steam generator, model of which is shown here, is the double tube construction which, when combined with double tube sheets, forms two walls to separate the liquid metal from the water and steam generated. The heat is transferred from the hot liquid metal inside the inner tubes which are expanded into the outer tubes throughout their entire length. Both tubes are expanded into separate tube sheets, so in case any tube joint should fail, the metal fluids would flow into an intermediate chamber. Fine grooves are formed on the outside of the inner tube, or on the inner surface of the outer tube, forming passages to permit the flow of a monitoring gas into the intermediate space between the tube sheets. Manufacturer is Griscon-Russell, Massillon, Ohio.

A NEW ROLLING MILL designed for processing pyrophoric materials used to make nuclear power fuel elements and other reactor structural materials. It is believed to be the first rolling mill based completely on remote control operation within an airtight enclosure (glove box) containing a helium atmosphere. Built by the Stanat Mfg. Co., 47-28 37th St., Long Island City 1, N. Y., two TA-725 rolling mills will be used mainly as experimental mills at Argonne National Lab. in the development of processing methods to roll radioactive materials like plutonium, uranium, zirconium, beryllium and thorium. A 2-high/4-high combination rolling mill, it has 2½ in. dia work rolls and 10 in. dia backup rolls in various roll face widths. Using needle roller bearings on the roll necks, the mill has a maximum rolling load capacity of 600,000 lb at a speed of 100 fpm. Besides rolling both flat stock, rounds, squares, and ovals, fuel element fabricators will have a single machine which can fulfill all their rolling requirements from the initial ingot to the final sheet.



THE PLASTIC MODEL shown here is that of a steel pressure vessel of a pressurized water nuclear reactor, which is being studied for the complicated stresses which exist in the shell under pressures up to 2000 psi. Made from a photoelastic plastic, the pressure vessel is about 2 ft high, 1½ ft in dia, and weighs about 100 lb. After the model is cast, it is machined to shape, and 4 psi of air pumped into it to duplicate its working pressure of about 2000 psi. The model is cured by heating which freezes the stress patterns. Samples are then cut out and studied under polarized light. The new photoelastic resin is said to be three times more sensitive in forming the desired stress patterns than previous materials. The photoelastic work is going on at the Westinghouse Electric Corp., Box 2278, Pittsburgh 30, Pa.

SCALES BUILT INTO a materials-handling crane are saving 40 per cent of the time formerly used in weighing materials for inventory control. Baldwin SR-4 crane scales are installed between the crane boom and the load, and the cab is equipped with a meter which indicates the weight of the materials. The two crane scales, made by Baldwin-Lima-Hamilton Corp., Waltham, Mass., have a capacity of 2500 lb, and are attached to the load as shown, with the SR-4 units carrying the full weight.



HIGH SPEED SEQUENCE PICTURES of rocket ejection seat, and cartridge ejection seat. (A) Arrow shows the standard M3 cartridge-actuated seat and dummy catapulted clear of the sled cab, while rocket seat, with rocket motor burned out is directly above it. Stream of smoke shows path of rocket seat. (2) In less than one second both seats are separate from dummy pilots. At this point the rocket propelled passenger is 124 ft above the ground compared with the 55 ft reached by the cartridge-ejected dummy. The rocket sled was traveling at 240 mph. Even at 590 mph the rocket seat threw the dummy 60 ft above the height of the vertical fin of the rocket sled. (3) Parachute of rocket propelled dummy is more fully opened, as chute of cartridge propelled dummy begins to balloon out. The rocket seat is visible at top, right. (4) Dummy from rocket seat, above, is making normal descent, while cartridge propelled dummy is not in a position for a good landing.

Jet Plane Ejection Seat is Rocket Propelled

If tests prove favorable, jet aircraft pilots who must abandon their planes will be shot out of the plane on a new rocket propelled ejection seat. According to reports, the rocket seat gives the pilot a good chance of ejecting safely from ground level in case of an emergency on takeoff or landing.

Thirteen major aircraft companies or divisions of companies are working cooperatively on the ejection seat development program, under the direction of the Air Research and Development Command and Convair. Objectives of the program are to develop a standard upward ejection seat applicable to all supersonic aircraft.

The series of photographs here shows the comparison of a new RESCU (meaning, Rocket Ejection Seat Catapult, Upward) Mark I unit with the standard M3 type cartridge catapult now used. Instrumented dummies, simulating pilots, were in the seats when ejected. Both parachuted to the ground without damage in a slow-speed (240 mph) run of a TF-102A nose section (has side-by-side seating) on a rocket sled.

However, the tests showed that the rocket propelled seat will insure greater clearance of the aircraft upon seat ejection, a reduction in the deceleration rate as the pilot and seat unit is catapulted into the airstream. Also the rocket-propelled seat had a much higher trajectory out of the cockpit than did the cartridge ejected seat. And while both parachutes opened successfully, the one attached to the dummy on the rocket-propelled seat blossomed more fully.

The rocket drives the seat forward as well as upward, softening the impact of the pilot on the strong airstream. With the rocket boost, the pilot decelerates more gradually. The acceleration on the discharge is built up gradually, compared to the sudden explosion of the M3 cartridge.

The standard M3 cartridge catapult is a three-tube telescoping device, with its power stroke limited to the maximum extension of these tubes before separation. At very high speeds, the air drag on the man and the seat causes binding of the tubes, and a reduction of the final ejection velocity.

Aluminum Impacts Have Surface Cladding

The Aluminum Company of America just announced that inexpensive aluminum impact extrusions will be available with a thin surface cladding which will give cathodic protection, facilitate finishing, and make joining easier. This is expected to open new avenues of application of such aluminum impacts, i.e., water filters, steam traps, electrical cases, small water tanks, and process industry operations where corrosive solutions or atmospheres are severe.

It will be possible to clad high strength parts with an alternate aluminum alloy which can be used for all types of finishing operations. In another application a thin layer of brazing alloy on either the inside or outside of the impact extrusion will simplify the joining of appliance parts and other assemblies.

The technique uses Alcoa's Alclad process where a thin layer of aluminum alloy is bonded to sheet or plate. This alloy offers good corrosion protection.

When clad by this method, it was found that the extruded parts are protected by the coating even when slight surface imperfections exist, a desirable feature in parts exposed to corrosive elements.

COMING EVENTS

JANUARY 14-16, 1957

3rd National Symposium on Reliability and Quality Control in Electronics, Hotel Statler, Washington, D. C. The theme will be a "Report to the Nation on the Present Status of Reliability." There will be two concurrent sessions for four periods during the days.

JANUARY 14-18

Society of Automotive Engineers, Annual Mtg. and Engineering Display, Sheraton-Cadillac and Hotel Statler, Detroit, Michigan.

JANUARY 16-18

13th Annual National Technical Conference of the Society of Plastic Engineers, Hotel Sheraton-Jefferson, St. Louis, Mo. Theme of the show will be "Fifteen Years of Plastics Progress." Technical session topics are: Tooling and Machinery; Atomic; Design; Extrusion; Injection; Foams: Applications; Reinforced Plastics; Instrumentation; Compression Molding; Polyethylene; and Epoxy.

JANUARY 21-22

2nd Industrial Economics Conference, Fairmont Hotel, San Francisco, Calif. Sponsored by Stanford Research Institute, the theme will be, "Implementing Long-Range Company Planning." Designed for the special interest of management executive sales managers, and research directors.

JANUARY 21-22

Solar Furnace Symposium, Hotel Westward Ho, Phoenix, Arizona. Session topics are: Design and Operation of Large Solar Furnaces; Furnaces for Basic and Applied Research; and Furnace Performance Determination and Control. Following the sessions will be a field trip to see a small furnace at the Arizona State College. There will be an address by Dr. C. C. Furnas, Asst. Sec. of Defense for Research and Development.

JANUARY 23-25

12th Symposium on "Instrumentation for the Process Industries," presented by the Chemical Engrg. Dept., Agricultural & Mechanical College, College Station, Texas. Designed to lead to an improved understanding of the principles and practices of instrumentation as applied to chemical industries.

JANUARY 24-27

General Management Conference of the American Management Association, Fairmont Hotel, San Francisco, Calif. Sessions will be on: Management Development Principles from Practice; A Practical Operating Management Development Program; Developing Effective Managers in the Small Company; Management Plans and the Washington Perspective; and others.

JANUARY 30-31

3rd Annual Midwest Welding Conference, Illinois Tech. Chemistry Bldg., 3255 S. Dearborn St., Chicago, Ill. Sponsored by the Armour Research Foundation and the Chicago Chapter of the American Welding Society. Nuclear reactor welding will be highlighted.

FEBRUARY 5-7

12th Annual Society of the Plastics Industry, Inc., Reinforced Plastics Div. Conference, Edgewater Beach Hotel, Chicago, Ill.

FEBRUARY 14-15

Transistor and Solid State Circuits Conference, sponsored by IRE and AIEE, Univ. of Penna, Philadelphia, Pa. Sessions are grouped under: Switching Circuits; Computer Switching; Linear Amplifiers; Power Circuits; and Special Device Circuits.

FEBRUARY 15-16

Spring Meeting, National Society of Professional Engineers, Hotel Francis Marion, Charleston, South Carolina.

FEBRUARY 26-28

The 1957 Western Joint Computer Conference, Statler Hotel, Los Angeles, Calif. Under the joint sponsorship of the IRE, AIEE, and ACM, the theme of the meetings will be "Techniques for Reliability."

MARCH 6-8

Spring Technical Meeting, Pressed Metal Institute, Carter Hotel, Cleveland, Ohio.

MARCH 11-15

The 1957 Nuclear Congress, Convention Hall, Philadelphia, Pa. Expected to attract engineers and scientists from all over the world, the Congress has as its purpose, the promotion of the use of atomic energy for peaceful purposes in all the nations of the world. The 5th Atomic Energy for Industry Conference will be held in conjunction with the Congress. Over 200 exhibitors will display equipment. In the engineering and science sessions will be 130 technical papers dealing with all phases of nuclear operations. Emphasis will be on new developments of potential value to civilian industry, especially in the field of metallurgy, chemical processing, and mechanical and power applications.

MARCH 13-15

Spring Meeting of the National Fluid Power Association, Hollywood Beach Hotel, Fla.

MARCH 18-21

SPI Annual National Conference and Pacific Coast Plastics Exposition, Los Angeles, Calif. Sessions will be held at the Hotel Biltmore, on plastics in the fields of electronics, aircraft and defense, packaging, building materials, appliances, sheet and cellular plastics, in addition to the latest developments for processes and processing. The Exposition will be held at the Shrine Exposition Hall.

MARCH 25-29

10th Western Metal Congress and Exposition, Pan-Pacific Auditorium, Los Angeles, Calif. The congress will be in the Ambassador Hotel.

APRIL 1-2

5th Midwestern Conference on Fluid Mechanics and the 3rd Midwestern Conference on Solid Mechanics, held concurrently at the Univ. of Michigan, Ann Arbor, Mich.

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plug mounting

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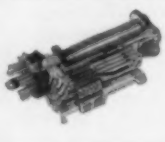
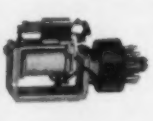
The "all-purpose" relay for use where first cost is important. Gives long, dependable service. Size: 4⅜" x 2⅛" x 1⅞".

CLASS B:
Made for extremes of long service life and dependability — often exceeding 400 million operations! Size: 4⅜" x 2⅛" x 1¼".



CLASS F:
Low operating power makes this relay especially desirable in a.c. circuits where relays function without specified operate or release time delays. Size: 4⅜" x 1 13/16" x 1¼".

CLASS S:
Made for exacting miniature requirements. Used in aircraft where resistance to shock and vibration is needed in a small, light, reliable relay. (For printed circuit applications—see below.) Size: 2⅛" x 2" x 1¼".



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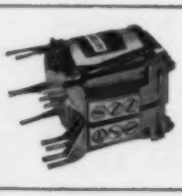

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Stress Cycles in Planetary Gears

LLOYD E. IVERSEN
Industrial Power Div. International Harvester Company

NOMENCLATURE

N_1 = number of teeth in sun gear (1)
N_2, N_3 = number of teeth in planetary gears (2) (3)
N_4 = number of teeth in internal or external (2nd sun) gear (4)
$(N_1)_c$, $(N_2)_c$ etc. = number of stress cycles per hour for 1st, 2nd etc. gears.
J = rph of driving member (input)
j = rph of driven member (output)
n = number of planets or planet pairs
T = output torque
t = input torque
Order of mesh for gears is 1,2,3,4.

WITH SIMPLE GEAR TRAINS where only two gears are meshing, the number of stress cycles that a particular gear tooth receives during its desired life is simply the hours of desired life multiplied by the revolutions per hour of the gear in question. When three gears are meshing in the same plane and where one drives another through an intermediate gear, the above rule applies only to the first and last gear. The center gear suffers from reverse bending and has twice the number of stress cycles.

Planetary gear drives have three basic members, one of which is prevented from rotating. Power is applied to one of the two remaining members, called the driver, while the other is the power take-off. It is not true to say, however, that any one of these members having zero rph has no stress cycles. Even knowing the rph of the other members does not predict accurately the number of stress cycles because of relative motion away or towards one another.

Below is a chart of formulas for calculating the cycles per hour per tooth of the indicated gears. The spider is the plate or web that orients the planets. When the spider is the driver it is the rph of the spider that is used.

EXAMPLE 1

A simple planetary gear train of the type illustrated (Table I) has 3 planetary gears (n = 3). The input, or driving member, is sun gear (1), fixed member is the annulus or internal gear (4). Output will thus be through planet carrier, or spider. Input speed is 1,500 rpm. It is equired to find no. of stress cycles of gears 1, 2, & 4 during train life of 10,000 hours.

SOLUTION

If no. of teeth in gears are $N_1 = 30$, $N_2 = 12$, $N_4 = 54$, then from Table I

$(N_1)_c = nJ[N_4/(N_4+N_1)] = 3(1500\times 60)[54/(30+54)]\times 10{,}000$
$= 17.4 \times 10^8$

$(N_2)_c = 2J[N_1N_4/N_2(N_1+N_4)] \times 10{,}000$
$= 2 \times (1500 \times 60)[30 \times 54/12(30+54)] \times 10{,}000$
$= 27 \times 10^8$ (Tooth will also be subjected to reverse bending.)

$(N_4)_c = nJ[N_1/(N_1+N_4)] \times 10{,}000$
$= 3 \times (1500 \times 60)[30/(30+54)] \times 10{,}000$
$= 96 \times 10^7$

(continued on page 221)

Table I—Planetary Gear System With One or More Single Planets

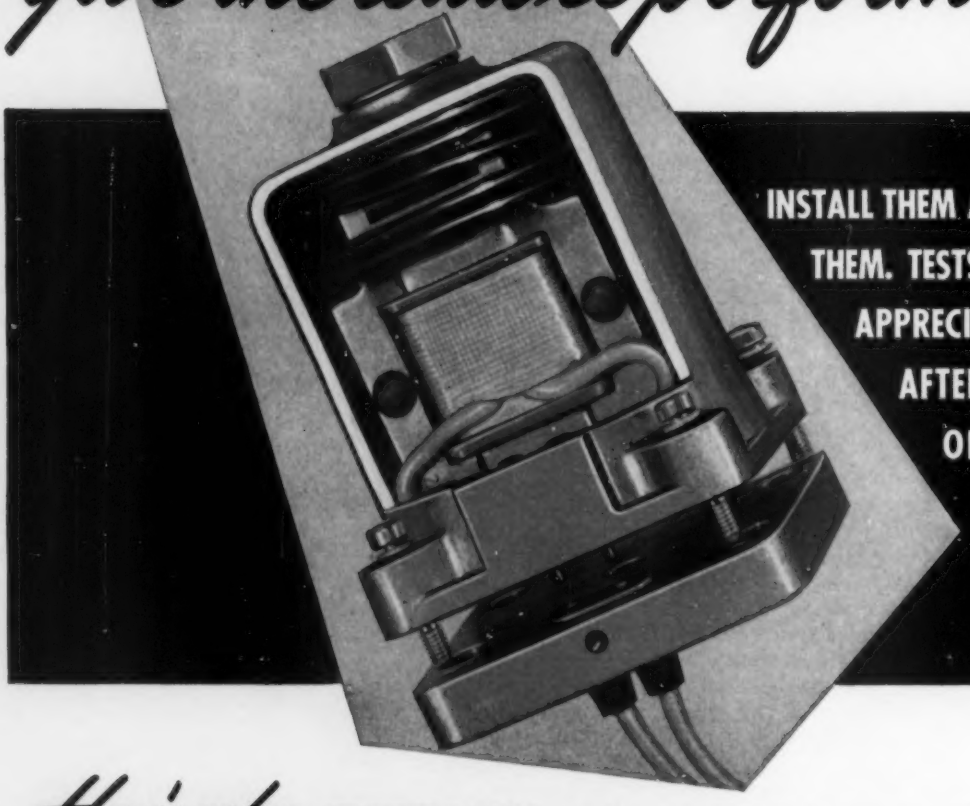
Fixed	Driver	$(N_1)_c$	$(N_2)_c$ (Reverse bending)	$(N_4)_c$
N_1	Spider	nJ	$2J\ N_1/N_2$	$nJ\ N_1/N_3$
N_4	Spider	$nJ\ N_4/N_1$	$2J\ N_4/N_2$	nJ
Spider	N_1	nJ	$2J\ N_1/N_2$	$nJ\ N_1/N_4$
Spider	N_4	$nJ\ N_4/N_1$	$2J\ N_4/N_2$	nJ
N_1	N_4	$nJ\ [N_2/(N_1+N_4)]$	$2J\ [N_1N_4/N_2(N_1+N_4)]$	$nJ\ N_1/(N_2+N_1)$
N_4	N_1	$nJ\ N_2/(N_2+N_1)$	$2J\ [N_1N_4/N_2(N_1+N_4)]$	$nJ\ [N_1/(N_1+N_4)]$

Where sun gear is input and spider is output:

Speed ratio $= V = j/J = N_1/(N_4+N_1)$
Torque ratio $= R = 1/V = (N_4+N_1)/N_1$
For 100% efficiency: $T/t = J/j$

Decco OIL-IMMERSED SOLENOIDS

give incredible performance



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Stress Cycles in Planetary Gears (continued from page 219)

Table II—Planetary Gear System With One or More Pairs of Planets

Fixed	Driver	$(N_1)_c$	$(N_2)_c$ (Reverse Bending)	$(N_3)_c$ (Reverse Bending)	$(N_4)_c$
N_1	Spider	nJ	$2JN_1/N_2$	$2JN_1/N_3$	nJN_1/N_4
N_4	Spider	nJN_4/N_1	$2JN_4/N_2$	$2JN_4/N_3$	nJ
Spider	N_1	nJ	$2JN_1/N_2$	$2JN_1/N_3$	nJN_1/N_4
Spider	N_4	nJN_4/N_1	$2JN_4/N_2$	$2JN_4/N_3$	nJ
N_1	N_4	$nJ[N_4/(N_1-N_4)]$	$2J[N_1N_4/N_2(N_1-N_4)]$	$2J[N_1N_4/N_3(N_1-N_4)]$	$nJ[N_4/(N_1-N_4)]$
N_4	N_1	$nJ[N_4/(N_1-N_4)]$	$2J[N_1N_4/N_2(N_1-N_4)]$	$2J[N_1N_4/N_3(N_1-N_4)]$	$nJN_1/(N_1-N_4)$

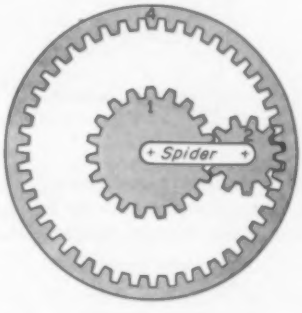
When spider is input and annulus (internal) gear is output:

$V = (N_4 - N_1)/N_4$

$R = N_4/(N_4 - N_1)$

Table III—Planetary Gear System With Stepped Planets and Internal Gear

Fixed	Driver	$(N_1)_c$	$(N_2)_c = (N_3)_c$	$(N_4)_c$
N_1	Spider	nJ	JN_1/N_2	nJN_1N_3/N_2N_4
N_4	Spider	nJN_2N_4/N_1N_3	JN_4/N_3	nJ
Spider	N_1	nJ	JN_1/N_2	nJN_1N_3/N_2N_4
Spider	N_4	nJN_2N_4/N_1N_3	JN_4/N_3	nJ
N_1	N_4	$nJ[N_2N_4/(N_1N_3+N_2N_4)]$	$J[N_1N_4/(N_1N_3+N_2N_4)]$	$nJ[N_1N_3/(N_1N_3+N_2N_4)]$
N_4	N_1	$nJ[N_2N_4/(N_1N_3+N_2N_4)]$	$J[N_1N_4/(N_1N_3+N_2N_4)]$	$nJ[N_1N_3/(N_1N_3+N_2N_4)]$



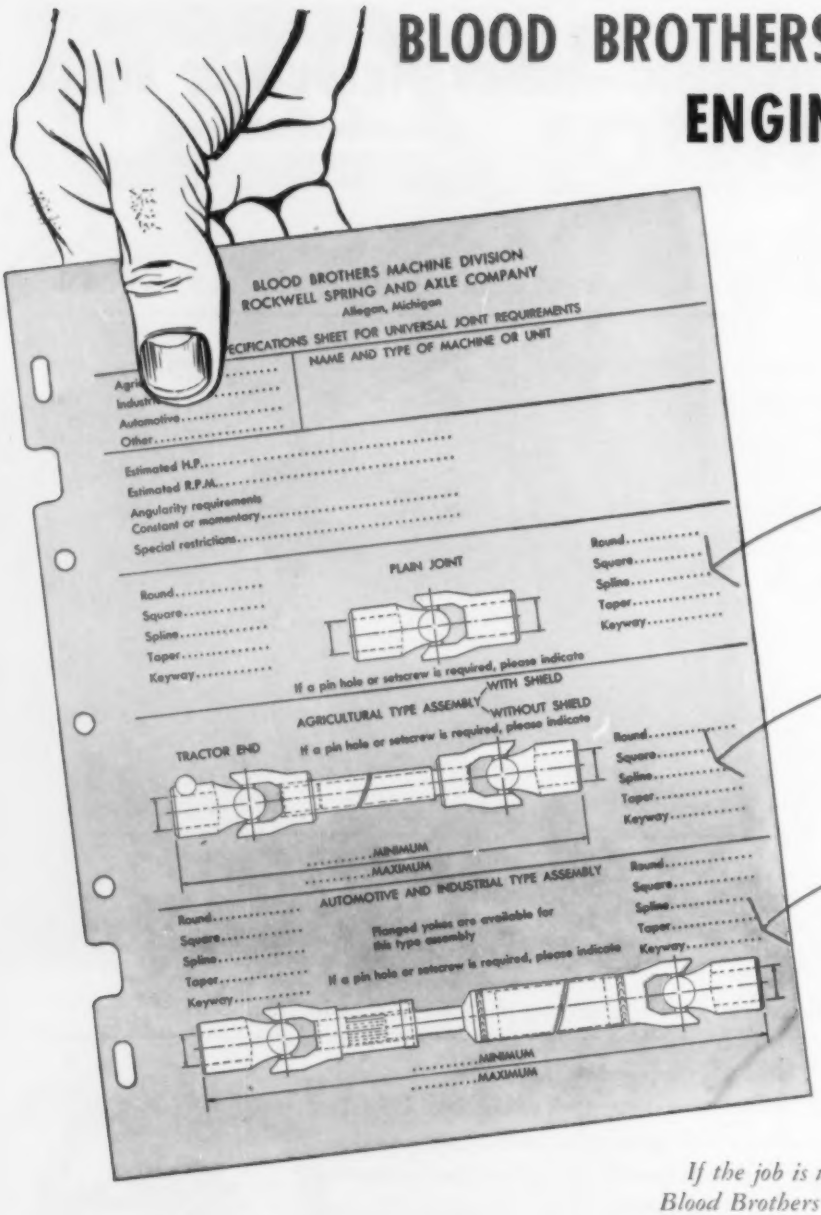
When sun gear is input and spider is output:

$V = N_1N_3/(N_1N_3 + N_1N_2)$

$R = (N_1N_3 + N_4N_2)/N_1N_3$

(continued on page 223)

BLOOD BROTHERS makes your ENGINEERING JOB *EASIER*



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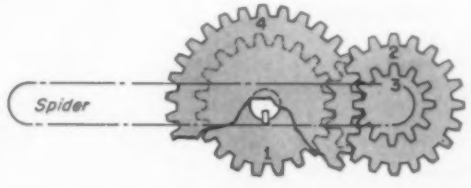
Stress Cycles in Planetary Gears (continued from page 221)

Table IV—Planetary Gear System With Stepped Planets and External Gear

Fixed	Driver	$(N_1)_c$	$(N_2)_c = (N_3)_c$	$(N_4)_c$
N_1	Spider	nJ	JN_1/N_2	nJN_1N_3/N_2N_4
N_4	Spider	nJN_2N_4/N_1N_3	JN_4/N_3	nJ
Spider	N_1	nJ	JN_1/N_2	nJN_1N_3/N_2N_4
Spider	N_4	nJN_2N_4/N_1N_3	JN_4/N_3	nJ
N_1	N_4	$nJ[N_2N_4/(N_2N_4-N_1N_3)]$	$J[N_1N_4/(N_1N_3-N_2N_4)]$	$nJ[N_1N_3/(N_2N_4-N_1N_3)]$
N_4	N_1	$nJ[N_2N_4/(N_2N_4-N_1N_3)]$	$J[N_1N_4/(N_2N_4-N_1N_3)]$	$nJ[N_1N_3/(N_2N_4-N_1N_3)]$

When sun gear is input and spider is output:

$$V = N_4N_2/(N_1N_3 - N_4N_2)$$
$$R = (N_4N_2 - N_1N_3)/N_4N_2$$



EXAMPLE 2

A planetary gear system has one pair of stepped planets (n = 1) and an external gear as illustrated in Table IV. Input is through the sun gear (1), fixed member is the spider. Output is through external gear (4). Driving member speed is 1,200 rpm. Required are no. of stress cycles in all gears, for a train life of 10,000 hours.

SOLUTION

If no. of teeth in gears are $N_1 = 28$, $N_2 = 20$, $N_3 = 12$, $N_4 = 35$, then from Table IV

$$(N_1)_c = nJ \times 10{,}000$$
$$= 1 \times (1{,}200 \times 60) \times 10{,}000$$
$$= 72 \times 10^6$$
$$(N_2)_c = (N_3)_c = JN_1/N_2 \times 10{,}000$$
$$= (1{,}200 \times 60)(28/20) \times 10{,}000$$
$$= 1{,}008 \times 10^6$$
$$(N_4)_c = nJN_1N_3/N_2N_4 \times 10{,}000$$
$$= 1 \times (1{,}200 \times 60)[(28 \times 12)/(20 \times 35)] \times 10{,}000$$
$$= 3{,}456 \times 10^6$$

EDITOR'S NOTE—Further information concerning planetary gearing can be found in the following Product Engineering articles:

"General Equations for Solving All Planetary Gear Ratios", 4th Product Design Digest Issue, page E12a. Solutions for all gear train arrangements are derived from one basic general equation.

"Whole Number Solutions of Indeterminate Equations for Gearing", May 1954, page 198, shows how a method of Diophantine equations can be applied to the solution of gear problems involving indeterminate equations. Method applies especially to planetary gearing.

"Formula for Epicyclic Gear Train of Large Reduction", Dec. 1954, page 213.

Important information on gearing also appears in:

"Wear Life of Aluminum Gears", Sept. 1956, page 160. An analytical procedure is given for estimating the probable life of aluminum gears.

"Methods of Specifying Precision of Spur Gears", Nov. 1956, page 135, includes methods of making measurements and converting AGMA and modified AGMA systems one to another.

"Effect of Gear Size on Gear Design Calculations", Apr. 1954, page 129.

Reversible Solenoid Valves With Replaceable

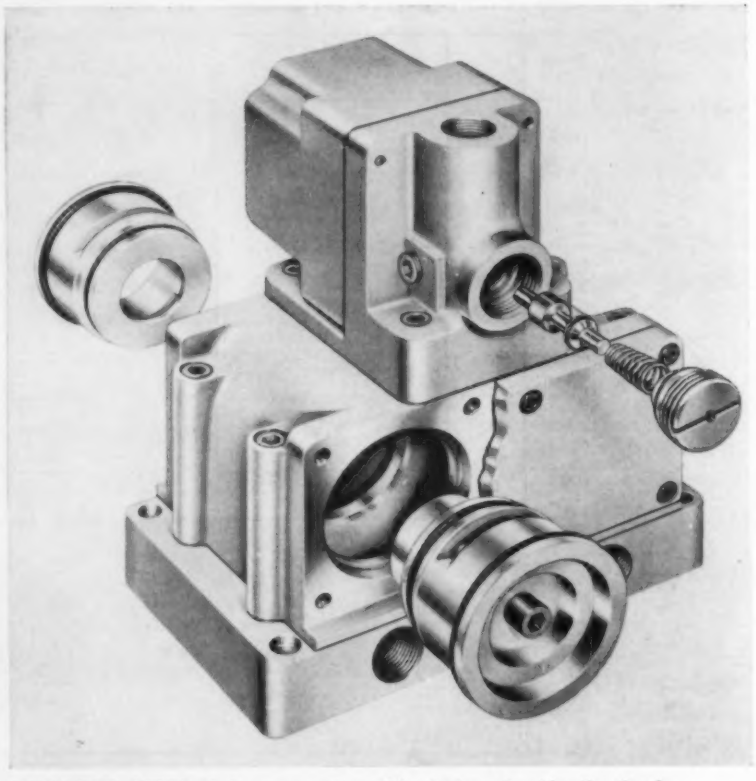
A ball check system in the pilot heads of these poppet-type air control valves automatically selects pilot pressure from whichever port is used as inlet. As a result, two and three-way valves can be piped normally open or normally closed to pressure; four-way valves can be piped with supply to either of two inlet ports to provide desired piping conditions. In all cases, there are no changes to make in the valve assembly. Piping to the proper port is the only type of change that is necessary.

Another function of the ball check system is to retain pilot pressure within the head after the piston-poppet has shifted in the valve. Inadequate supply to the valve and loss of pilot pressure after the piston-poppet has shifted is a frequent cause of malfunction in some poppet-type valves, according to the manufacturer. The requirement of full-size piping to the valve is eliminated with the ball check system used in these solenoid-controlled units.

Subplate mounting is provided in all valves in the new line. A complete valve assembly can be replaced in less than 2 min, by loosening the four mounting screws that hold the valve body assembly to the subplate. Piping need not be disturbed. Similarly, pilot heads are quickly replaceable as a unit simply by removing the four screws which are used to attach it to the valve body.

A valve of this design can be completely serviced or its operating cycle changed even in the line, in less than 15 min, it is claimed.

The cover plates of the valve body, when removed, give immediate access to the piston-poppets and inserted valve seats. These parts are removable as complete assemblies. Unscrewing the pilot stem retainer allows the only moving part of the pilot head to be replaced. Solenoids may be lifted from the locating pins simply by loosening the four cover screws. This part is also separable from ball check housing.



EXPLODED VIEW of four-way valve with single solenoid pilot head.

Servicing of more than 100 valve combinations is possible with less the 25 individual parts. As a result, fewer models will satisfy more applications.

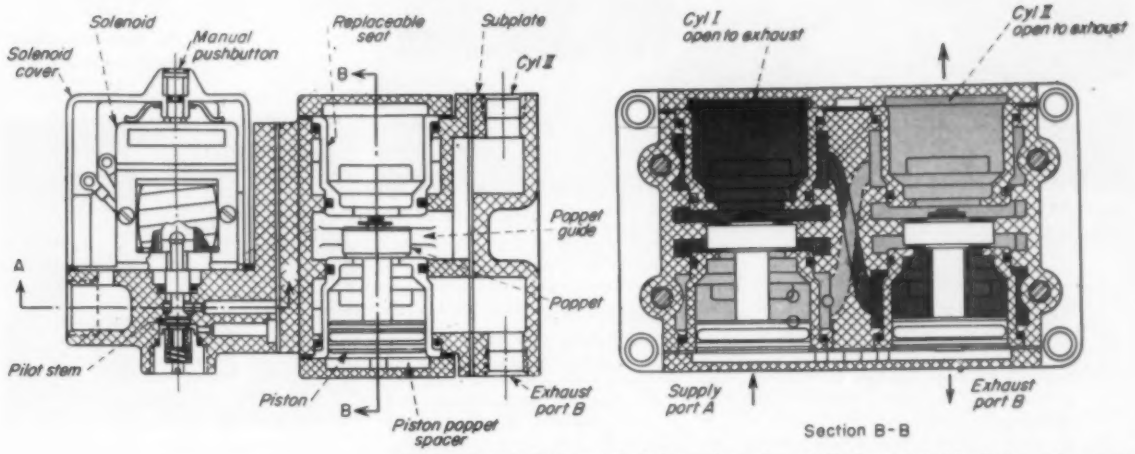
All poppet seats in the valve body and in the pilot heads are replaceable. Since poppets do not seat on the valve body at any point, damage to any seat is not serious, since it can be quickly and inexpensively repaired or even replaced.

All internal passages of the new valves are larger than the cross-sectional area of standard pipe sizes with which each model is to be used. Since both piston-poppets and pilot head poppets are short stroke, speeds in excess of 600 cpm are practicable with these valves.

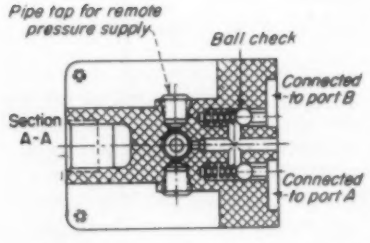
Expected applications for the three-way valves include: control of single-acting (spring-return) cylinders, double-acting cylinders, two-pressure operation of a double-acting cylinder and to provide directional control.

Four-way valves will likely be used to obtain reciprocating action with double-acting cylinders, to operate long-stroke, double-acting cylinders when maximum speed is not of prime importance, to obtain fast action and quick reversal of short-stroke cylinders to provide control of low-pressure and vacuum operation, to control fluids other than air.

Poppet Seats Are Ball-Check Controlled



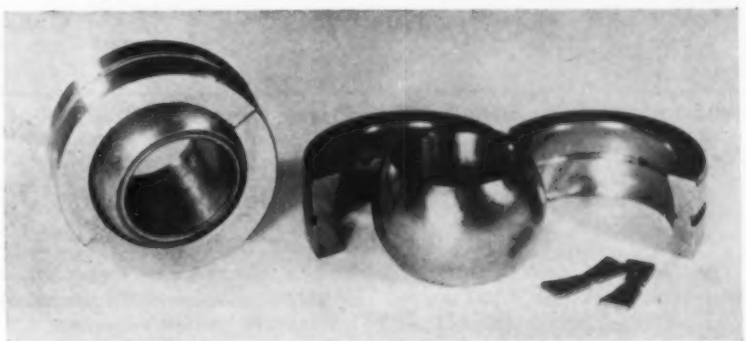
CROSS-SECTIONAL at left, below, shows how ball check is held off (or on) seat at all times by pressure. De-energized flow shown at right, above. Pressure, introduced behind pistons, forces poppets across to opposite seats.



Designed to operate with air pressures to 150 psi, and hydraulic pressures to 250 psi, any of these valves may be adapted to vacuum service. The synthetic rubber seals that are used in this line of controls are suitable for service temperatures ranging from 0 to 250F.

The complete line requires only four valve bodies. They are: $\frac{1}{4}$-$\frac{3}{8}$ in., two and three-way; $\frac{1}{2}$-$\frac{3}{4}$ in., two and three-way; $\frac{1}{4}$-$\frac{3}{8}$ in., four-way; $\frac{1}{2}$-$\frac{3}{4}$ in., four-way. Either side or bottom-ported subplates are available on four-way models. Three types of pilot control heads are provided, master (air), single and double solenoid. They are interchangeable on all two, three and four-way valves, regardless of pipe size of the particular unit. Galland-Henning Mfg. Co., 2753 S. 31 St., Milwaukee 46, Wis.

For more information—
Circle 1, inside back cover



Spherical Bearing

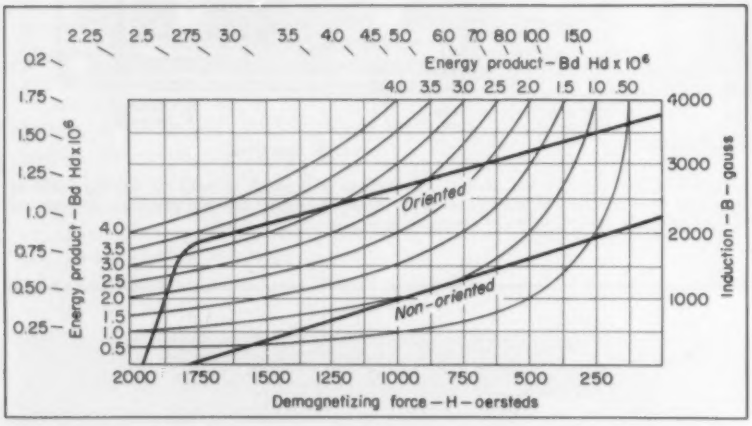
A spherical bearing has been developed that is manufactured at present in $\frac{3}{4}$ to $1\frac{1}{2}$ in. shaft sizes. Additional sizes up to 6 in. are being planned. Better lubrication is claimed for this bearing, through a cross-hatched, oil-grooved surface finish on both ball and socket. The balls are heat-treated, bores are honed and the sockets are of a softer type of material.

The socket is split on the horizontal center line like a conventional bearing and the bore in which it is mounted completes the assembly. The sockets are machinable and easily altered, adapting them to several methods of anchorage to machine parts. Ralph F. Stallman, 4800 Reinhardt Drive, Oakland 19, Calif.

For more information—
Circle 2, inside back cover

CONTINUED ON PAGE 226

ELECTROMAGNETIC STATOR (left) and oriented permanent magnet, together with rotor of the type with which such components are used.



DEMAGNETIZATION and energy product curves for non-oriented magnets.

Oriented Ceramic Permanent Magnets

An oriented ceramic permanent magnet material, that is said to produce an extremely high peak energy product, is expected to make possible savings in both magnetic material and space. Made of a newly developed ferrite magnetic material, which is oriented in the direction of pressing, Indox V produces a peak energy product of approximately 3.5 x 10^6, as compared to 1.0 x 10^6 for Indox I, which is non-oriented.

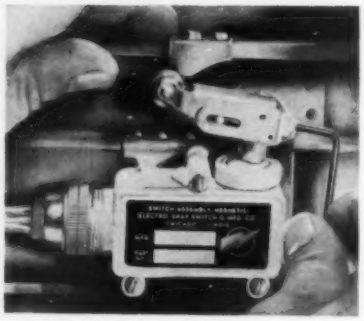
On an equivalent weight basis, the new ceramic magnet's light weight (0.181 lb/cu in.) makes its energy comparable to Alnico V. Because of its extremely high coercive force (2000 oersted), length required is 28 per cent that of Alnico V at optimum operation. The area is 57 per cent of non-oriented ceramic magnets.

Residual induction (B_r) is 3840 gauss. At the point of peak energy product, there is a flux density (B_d) of 1920 gauss and demagnetizing force 1820 oersted. The new product provides a wider high-efficiency operating range than Alnico V because the maximum energy product does not have a sharp peak.

Another advantage is that this magnet material contains only non-critical materials. Other properties include resistivity on the order of 10,000 to 20,000 ohm-cm, and a low incremental permeability.

Indox V is well suited for applications such as d-c motors, synchronous drives, TV focusers, traveling wave tubes, loud speakers, magnetic clutches, and a variety of tractive devices where size is important. Indiana Steel Products Co., Valparaiso, Ind.

For more information—
Circle 3, inside back cover



Switch with Adjustable Actuator

The actuator arm can be adjusted infinitely through an arc of 14 deg and can be altered upon or after installation to meet specific requirements. Single-handed adjustment is made by rotating adjusting screw to the desired setting, which permits a constant check of the operation with the other hand. Fixed actuator position is maintained permanently by a locknut at the rear of the actuator. The adjustable roller arm actuator is excellent for direct, cam or slide operation. Rated at 10 amp, 125-250 v a-c, 28 v d-c inductive. Electro-Snap Switch & Mfg. Co., 4218 W. Lake St., Chicago 24, Ill.

For more information—
Circle 4, inside back cover

Self-Wedging Nut

This self-locking nut is made of four parts: an outside shell that holds two tapered wedges, and a cap that keeps the two wedges in the outside shell. The two wedges, in combination with the external cone, interlock when slipped into position on a threadless rod, so that they have a

CONTINUED ON PAGE 228

FOR chemical processing OF ANY METAL... turn to Turco...FIRST!

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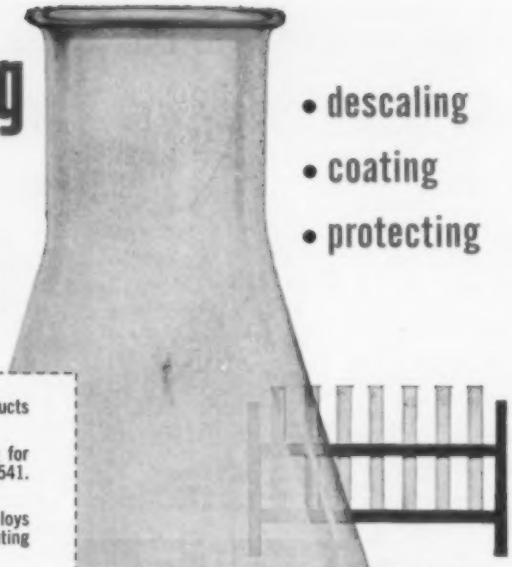
- protecting



ALUMINUM	**DESCALING:** Complete line of deoxidizing and polishing products for all alloys of aluminum. **COATING:** Economical and "quick fixing" conversion coating for application by spray, dip or hand methods. Approved to MIL-C-5541. Insures paint adhesion, stops aluminum corrosion. **PROTECTION:** Alkali-removable protective film for aluminum alloys both during storage (in plant and outdoor) and during fabricating practices.
STEEL	**DESCALING:** Complete line of alkaline and acid descaling media. **COATING:** Full line of iron, zinc and manganese phosphate compounds to provide a tight coating for better adhesion of organic finishes and for oil absorption. These materials all meet the various requirements of applicable government specifications. **PROTECTION:** Versatile group of products for protection of parts from the elements.
TITANIUM	**DESCALING:** Approved and accepted process for conditioning and removing scale from all current titanium alloys, both after heat forming to 1150° F. and heat treating to 1750° F. **COATING:** Acceptable anti-galling and seizing conversion coating for the major alloys of titanium. Also used as base for lubes. Requires no post-heat treatments. **PROTECTION:** Easily removable coating to protect titanium against tightly adhering scale up to 1600° F. during hot forming or heat treating.
STAINLESS STEEL	**DESCALING:** Process for completely removing heat scale from various alloys (including 17-7 PH). **COATING:** Easily removable coating to protect stainless steel against tightly adhering scale up to 1600° F. during hot forming or heat treating.
MAGNESIUM	**DESCALING:** Non-electrolytic alkaline process for removing previous chrome pickle films as well as oily substances often found on magnesium. **COATING:** One-package powdered product which, when in solution with water, replaces Dow #17 treatment. Requires no mixing of chemicals. Eliminates chance of human error. **PROTECTION:** Single-package touch-up liquid to produce coatings equal to Dow #18 treatment. (Note: All magnesium processes mentioned above are approved for use by Magnesium Department, Dow Chemical Co.)

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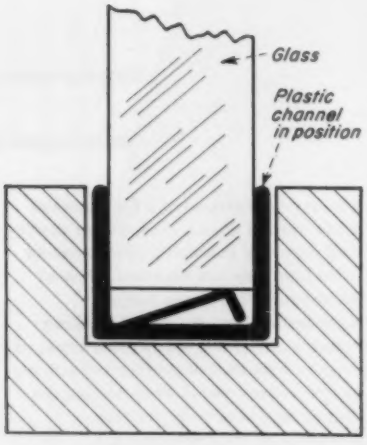
TITLE ____

PE

locking grip. The rows of teeth on the wedges abrade the rod. In tensile tests, according to the manufacturer, the rod will break at full strength.

These nuts are currently available in $\frac{1}{4}$, $\frac{3}{8}$ and $\frac{1}{2}$ in. shaft sizes. Morrow Mfg. Co., Inc., RFD 1, Old Baptist Road, E. Greenwich, R. I.

For more information—
Circle 5, inside back cover



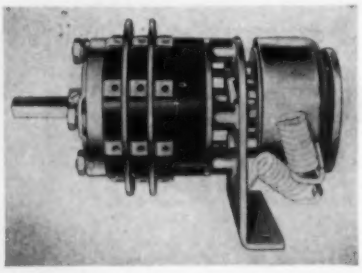
Mounting for Glass Panel

The mounting consists of a Tenite plastic channel with an integral, shock-absorbing cushioning spring inside the channel. The material is said to be flexible enough so that it will grip the glass panel with both legs and can be installed on the glass before assembling the glass into the frame. These extruded channels are made to specifications and can be designed to accommodate any glass thickness. Anchor Plastics Co., Inc., 36-36 36 St., Long Island City, N. Y.

For more information—
Circle 6, inside back cover

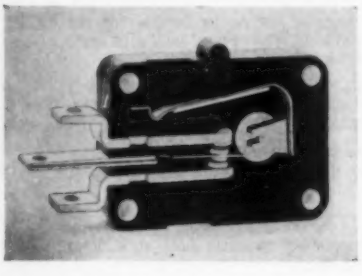
Solenoid-Operated Rotary Switches

Heavy-duty rotary multipole switches, assembled with solenoid rotating devices that drive the switch through the cycle of contact positions, provide remote automatic or semi-automatic control of a series of complex circuits. The indexing stroke of the solenoid device is matched to the degree of rotation between contact positions of the switch, and drives the rotor one position each time the solenoid circuit is closed. This circuit may be closed by pushbutton or by simple mechanical motion of the governed machine, providing the control needed for automation.



The electrical load and environmental conditions determine the rotary switch and solenoid rotating device that must be used. Electro Switch Corp., Weymouth 88, Mass.

For more information—
Circle 7, inside back cover



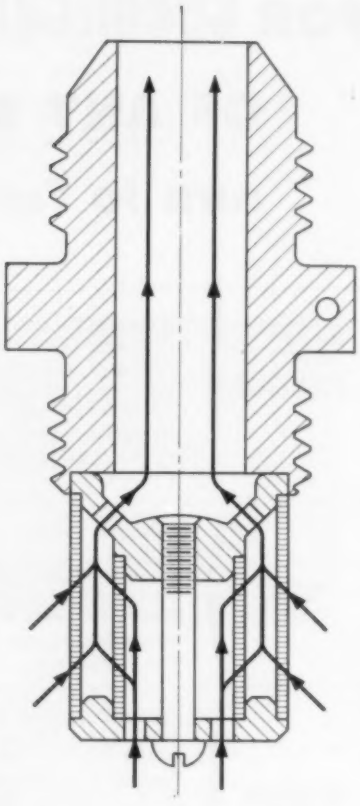
Cam-Actuated Snap Switch

A snap switch has been developed which is said to eliminate arcing and vibratory contact during actuation. This action is achieved by a mechanism which provides an ever-increasing pressure contact immediately before the actual breaking phase. The switch can make positive, completely noise-free contact in less than 450 microsec. C. Torres Engineering Co., S. Hackensack, N. J.

For more information—
Circle 8, inside back cover

Valve Protector for Hydraulic Systems

A two-way union-filter to protect hydraulic system valves and other components consists of two frameless wire-wound filter elements welded to a union. The unit can handle the flow of hydraulic fluid in either direction. The filter will stop all particles down to 0.003 in. in size. Unions can be made in all AN sizes for standard aircraft practice and are available in aluminum, stainless or plated steel. Purolator Products, Inc., Rahway, N. J.

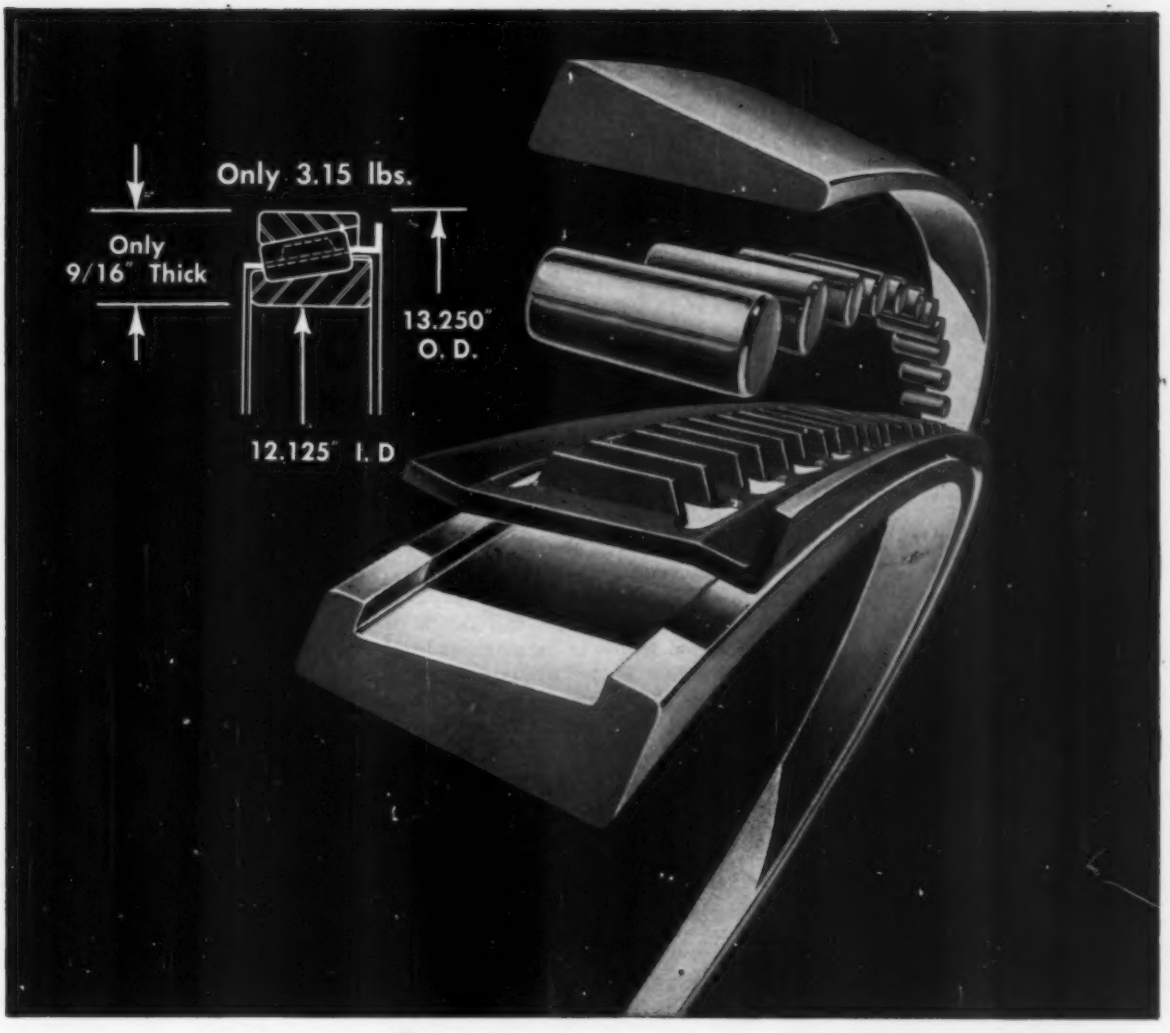


For more information—
Circle 9, inside back cover

Compass and Ellipsograph

This instrument is easily converted from a beam compass to an ellipsograph, which draws ellipses with any radii from $\frac{7}{16}$ to 12 in. and to any degree from 10 to 65 deg., without the limitations of ordinary french curves or other devices. As a simple beam compass, the principal components are two aluminum blocks which move freely along the length of the beam. One block holds a

—CONTINUED ON PAGE 230



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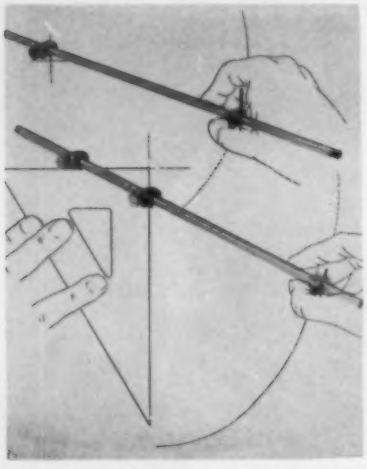


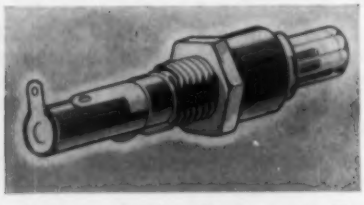
pivot pin, the other a lead point. Adjustment is provided for circles up to 24 in. dia. Aero Engineering Sales Co., P. O. Box 85, Azusa, Calif.

For more information—
Circle 10, inside back cover

Gear Reduction Pulley

This drive contains a gear reduction unit inside a pulley. Equipment can be narrower in width and without overhang on the drive side, according to the maker. Variable speeds are obtainable with this drive pulley by mounting motor equipped with a variable pitch pulley on sliding base. Bunke-Musser, Inc., Dept. 117, Jackson Center, Ohio

For more information—
Circle 11, inside back cover



Thermostat for Up to 700 F

A general purpose thermostat, with temperature ranges up to 700 F, is designed for such applications as deep-fat fryers, coffee urns, ovens, sterilizers, water and oil heating, metal platens, process ovens, degreasing tanks, melting pots, and compressed air heaters. Copper bulbs and capillaries are supplied for applications up to 250 F, and steel bulbs and capillaries for use up to 700 F. Switching mechanism is double-pole, single-throw, snap-action, normally closed or normally open, for a-c operation. General Electric Co., Schenectady 5, N. Y.

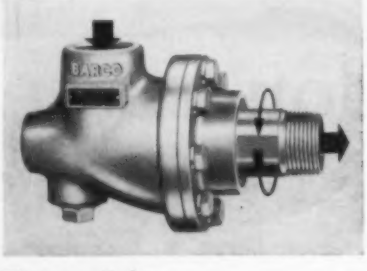
For more information—
Circle 12, inside back cover

Subminiature Snap-Action Switch

This switch is for operation in a temperature range of −65 F to 250 F. A built-in metal leaf actuator allows for actuation at any point and provides protection for the neoprene housing.

Hermetically sealed, this switch is designed for use in hazardous and exposed locations and will operate safely immersed in liquid or gas. Switches are available in three different circuit designs; single-pole, double-throw; single-pole, normally open and single-pole, normally closed. Dimensions are $\frac{7}{8}$ x $\frac{3}{8}$ x $\frac{3}{8}$ in. wide. Milli-Switch Corp., 1742 Berkeley St., Santa Monica, Calif.

For more information—
Circle 13, inside back cover



Rotary Joint

A rotary joint for use on steam, air, water, oil, gas, or alternating hot and cold service is suitable for pressures from 0 to 200 psi, steam; to 400 psi, hydraulic; for temperatures to 450 F. The unit is said to be able to operate at any ordinary rotating speed. It is now being produced in eight standard sizes from $\frac{1}{2}$ to 3 in. Barco Mfg. Co., Dept. J-34, 500 Hough St., Barrington, Ill.

For more information—
Circle 14, inside back cover

Expansion Joints

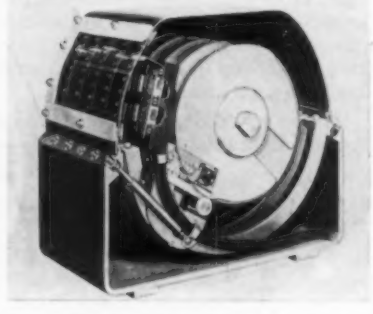
Series 50 joints are for lower line pressures while joints in Series 150 and higher are for higher pressures. The shape of the corrugations which form the flexing member are said to give each corrugation a more effective height, which results in greater flexibility and therefore more uniform movement per corrugation. Joints are available with either flanged or welding ends. At slight additional cost, all joints may be provided with external covering shields. Badger Mfg. Co., 230 Bent St., Cambridge, Mass.

For more information—
Circle 15, inside back cover

Cam Limit Switch

A rotating cam limit switch with 15-amp contacts, designed to synchronize multiple operations, has a micrometer screw adjustment of each individual switch mechanism in relation to its cam. This adjustment can be made with a screwdriver, from the outside, while the switch is in motion.

The switch is made in three standard sizes accommodating up to five, nine, or twelve cams. The split butterfly cams can be set with a spread between circuit "make" and "break" of from 15 to 345 deg., with external in-motion adjustment of ± 15 deg.

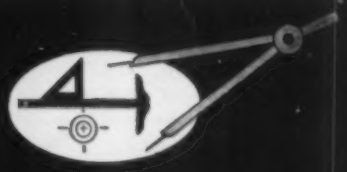


CONTINUED ON PAGE 232

USING

DU PONT ELASTOMERS

neoprene · Hypalon®



in design

New NEOPRENE closure strip weatherproofs corrugated roofing and siding

Tire sidewall of HYPALON® stays white, resists sunlight, ozone

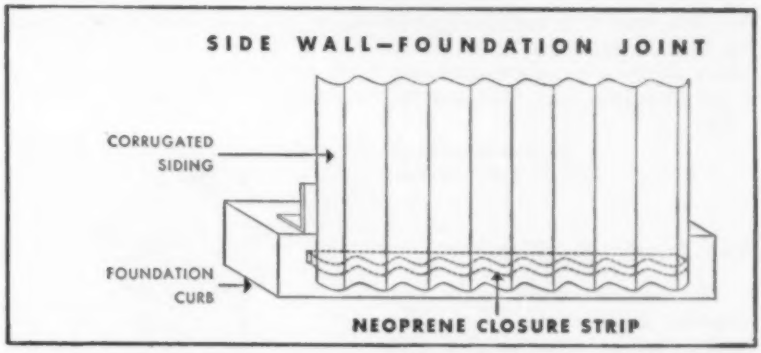
A leading tire manufacturer has greatly improved the appearance and performance of whitewall tires by using a special rubber compound which includes a substantial amount of HYPALON, Du Pont's new synthetic rubber. Road tests in the Los Angeles area show that the inclusion of HYPALON keeps the sidewall from cracking and becoming discolored.

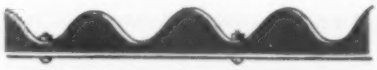
Chief reason for this success is the outdoor stability of HYPALON. Minute traces of ozone in the air are the primary cause of whitewall deterioration, but HYPALON is *completely unaffected by ozone*. It also withstands sunlight, weathering and discoloration far better than other kinds of rubber.

Idea for extra-long service

HYPALON also has many other properties of interest to designers. It shows unusual resistance to hardening at elevated temperatures (250°-350°F.) and has excellent resistance to solvents and chemicals, including strong oxidizing agents. These properties make HYPALON a wise choice for use in many industrial products, such as gaskets, molded parts, diaphragms, belt, hose—any resilient product that must give long cost-saving service where service conditions are severe. Just clip coupon for more information about HYPALON.

Lasting whiteness for sidewalls is now a reality with HYPALON. This versatile synthetic rubber can also be compounded in an unlimited range of light-fast colors.





(Above) Diagram shows position of neoprene closure strip on side wall. (Left) Close-up shows manner of bolting neoprene strip to flashing section.

Elastic strip withstands temperature extremes... eliminates caulking

A new neoprene closure strip has been developed which, according to the manufacturer, will solve the problem of weatherproofing corrugated roofing and siding. Only an inch wide, this non-porous closed-cell neoprene closure strip is die-cut to fit corrugations, forming a snug seal. Neoprene's long service life assures lasting protection for a building's exterior from dust, dirt, water and air—at minimum maintenance.

The closure strips are installed on roofing under the aprons of ridge roll and under flashing sections at roof junctions and side walls. They're fastened at the same time as the corrugated sheeting. No separate caulking is required.

Neoprene's elasticity and lasting resistance to weathering, temperature extremes and aging are vital to the success of the closure design. The strip *stays* elastic, won't become brittle and then crack in cold weather or become soft and sticky in hot weather. You may find just the properties your designs need in neoprene, Du Pont's versatile synthetic rubber. For more information, just clip the coupon.

Hundreds of feet of neoprene closure stripping are used at roof, side wall, window and door junctures of this typical building.

DU PONT

REG. U. S. PAT. OFF.

HYPALON *is a registered trademark of E. I. du Pont de Nemours & Co. (Inc.)*

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Elastomer Chemicals Dept. PE-1
Wilmington 98, Delaware

*Name*_____
*Firm*_____
*Address*_____
*City*_____ *State*_____

Contact assemblies may have two sets of contacts, one normally-closed and the other convertible—either normally open or normally closed. Contact operating arms bearing on the cams have nylon rollers which virtually eliminate wear. Both fixed and moving contacts can be inspected from the outside through a transparent panel in the oiltight case. Cams are individually adjustable and removable without disturbing other cams. Contacts can be removed and replaced without disassembling the switch. The switch is designed to operate at speeds up to 100 rpm, and rotation can be either clockwise or counter-clockwise. Clark Controller Co., Cleveland 10, Ohio

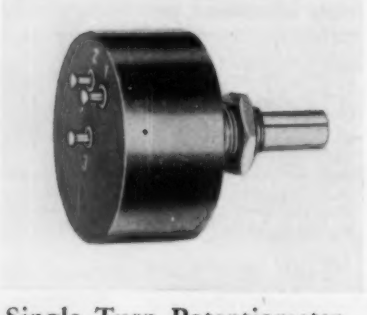
For more information—
Circle 16, inside back cover

D-c Power Rectifier

This regulated power supply uses magnetic amplification to maintain selected output voltage within ±10 percent variation in input voltage. Input is 208, 220, 440 v, three-phase, 60 cps; output: 44 or 52 v, 60 amp.

Design employs a three-phase bridge circuit, selenium rectification, and magnetic amplifier. Rapid Electric Co., 2881 Middletown Road, Bronx 61, N. Y.

For more information—
Circle 17, inside back cover



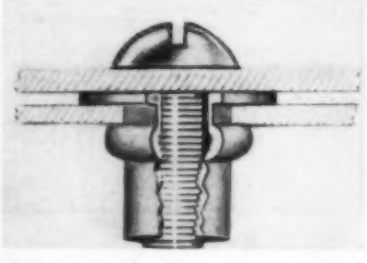
Single Turn Potentiometer

This potentiometer, with an operating temperature range of −55 C to 100 C, is said to have application possibilities in instrumentation and general servo-mechanism usages. Weighing approximately 1½ oz, the unit is 1 1/16 x 3/4 in. long, beyond bushing. The single-turn unit has a total resistance range of 50 to 40,000 ohm, with linearity as close as ±0.25 per cent. Electromath Corp., 190 Henry St., Stamford, Conn.

For more information—
Circle 18, inside back cover

Self-locking Nylon Nut

This fastener is an unthreaded nylon nut that snaps into a square hole in the inner surface of the materials being joined. It has self-retaining features so that it can be inserted



during production runs without danger of being dislodged during handling.

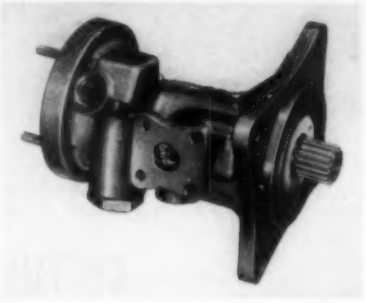
A self-tapping screw driven into the nut by either hand or power tool engages the mating portion and impresses its own threads on the inner wall. As the screw is tightened the counterbored section is drawn upward and outward, forming a rigid collar behind the lower side of the inner piece of metal, and locking it in place. Tru-Lock Fasteners, Inc., Woodbury, Conn.

For more information—
Circle 19, inside back cover

Two-Element Oil Pump

Both elements have built-in check valves to prevent a reverse flow, and the hydraulic element incorporates a pressure relief valve. Pump is positive displacement, rotary vane type. Mounts on accessory drive of gas turbine engine equipped with spline drive.

Capacity at 3750 rpm is 60 psi gage discharge pressure at 176 C. Hydraulic relief valve is set to by-pass full flow from the hydraulic element at 150 psi when fluid recirculates within the pump. Lear-Romec Div., Lear, Inc., Elyria, Ohio



For more information—
Circle 20, inside back cover

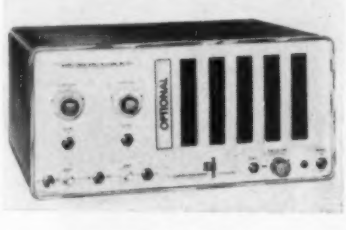
Vinyl-Coated Steel and Aluminum

An adhesive is applied to the metal and heated to high temperatures. After cooling, a film of liquid vinyl is applied 0.002 to 0.020 in. thick. The material is then brought to a high temperature again, and embossed. Coiled metal which can be processed into either sheet or strip is provided. Sun Steel Co., 1702 W. 74 St., Chicago 36, Ill.

For more information—
Circle 21, inside back cover

Time Interval Meter

This instrument is designed for measurement of elapsed time between two events occurring in the range of 10 microsec to 1 sec. Optional features include extension to 10 or 100, 000 sec. Accuracy is ± 10 microsec. The measurement interval may be started and stopped by independent or common voltages representing opti-



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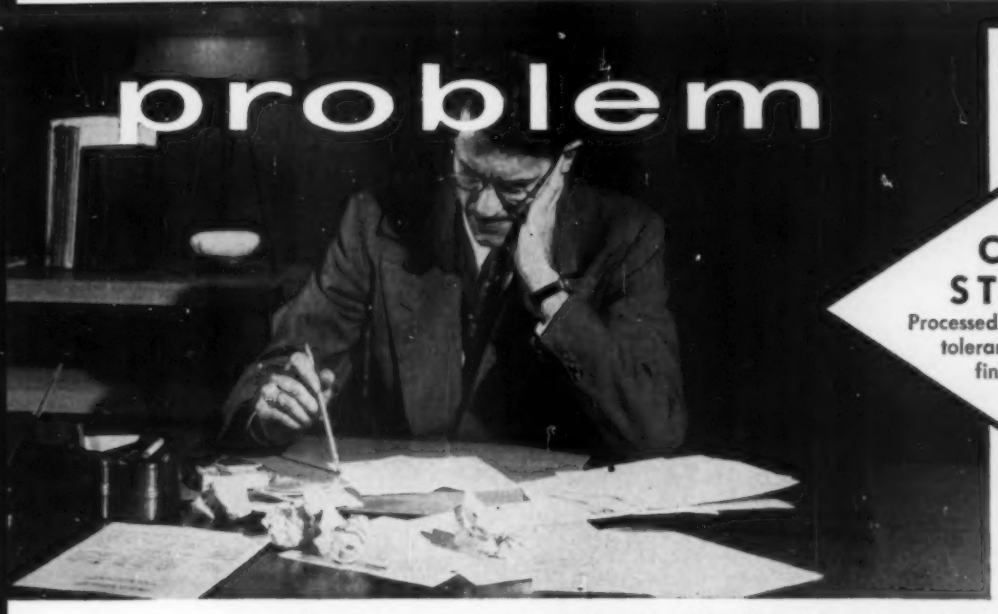

CMP
RESTRICTED SPECIFICATION
COLD ROLLED STRIP STEEL
Processed to meet special gauge tolerances and provide special finishes and physical properties . . . solves many fabrication, cost & performance problems.

Helping to overcome metal fabricating difficulties, improving products without skyrocketing costs or just getting costs down are usual events with **CMP.**

For example, the manufacturer who was heat-treating formed steel parts subsequently assembled with other components into a powered unit. The forming involves severe deformation and was hampered by lack of uniformity in the annealed strip steel. Distortion in the heat treatment followed, resulting in a low percentage of finished assemblies passed as satisfactory.

To minimize these fabricating difficulties, **CMP** developed a special annealing process for the strip. Using this steel, parts, when subjected to the manufacturer's standard heat-treating practice, were acceptable and yield was greatly increased.

At **CMP,** processing cold rolled strip steel to restricted specifications has been reduced to an exact science and **CMP** men have been trained to spot opportunities for solution of production cost and product improvement problems through application of restricted specifications.

Why not put your problems up to a **CMP** man?

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CMP
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COLD ROLLED STRIP STEEL
is available in
Low Carbon Grades • High Carbon Spring Steel (annealed and tempered) • Stainless Types • Alloy Grades • Electro Zinc Coated

cal, mechanical or electrical events. Computer-Measurements Corp., 5528 Vineland Ave., N. Hollywood, Calif.

For more information—
Circle 22, inside back cover

Subminiature Relays

Two-pole, subminiature relays have dimensions of ¾ x ⅝ in. length (larger model is 1⅝ in. long). Coil sensitivity is 60 or 25 milliw per pole depending on the model. Ambient temperature range is –65 to 125 C. U. S. Relay Co., 1744 Albion St., Los Angeles, Calif.

For more information—
Circle 23, inside back cover

Rigid PVC Pipe

PVC pipe is available in all standard pipe sizes from ¼ to 6 in. Easton Plastic Products Co., Inc., Easton, Pa.

For more information—
Circle 24, inside back cover

Electronic Speed Control

This device is available in capacities from 30 to 150 hp. It consists of an operator's control station, electronic control unit and a d-c motor. The electronic control is comprised of an ignitron-controlled, three-phase, full-wave rectifier system with its associated firing circuits; variable field supply; tachometer feedback; protection and switchgear circuits. Dynamic braking, reversing, forward-reverse jog operation, tachometer feedback, acceleration and armature current-limiting are included as standard features of the drive.

With the exception of the d-c motor, all components are static and have no inertial properties to slow down system response. Size is 5 x 5 x 2½ ft, up to 100 hp. Raytheon Mfg. Co., Waltham 54, Mass.

For more information—
Circle 25, inside back cover

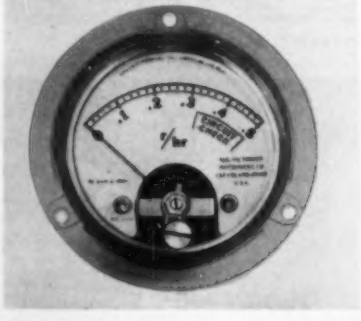
Coincidence Thyratron

This thyratron may be used in circuits where the coincidence of two or three signals should fire the tube. The device may find application in computers, automation control apparatus, coding or programming devices, counters. The KP-80 has three control grids, and for example, when it receives three simultaneous signals, the tube conducts, closing a relay in the anode circuit. KIP Electronics Corp., Dept. R-1, Stamford, Conn.

For more information—
Circle 26, inside back cover

Panel Meter

The lens, flange and case of the meter are a one-piece molding of clear butyrate plastic. The butyrate is



treated with anti-static compound to prevent static charges from disturbing the meter readings. Base is molded 90 durometer rubber. Dimensions are: 2.69 OD, arc length, 1.75 in. Assembly Products, Inc., Chesterland, Ohio

For more information—
Circle 27, inside back cover

Synchronous Clock Movement

This 2½ in. dia fully enclosed unit with synchronous electric motor drive has hour, minute and second hand arbors and is complete with back-setting knob. A threaded center mount-

ing bushing and nut are provided for mounting.

Movements can be supplied for either 115 or 230 v, 60 cps. Haydon Mfg. Co., Inc., 245 E. Elm St., Torrington, Conn.

For more information—
Circle 28, inside back cover

T-Slot Bolts

These bolts are made of aircraft quality alloy steel, forged and heat treated to provide a minimum tensile strength of 150,000 psi. Manufactured to JIC standards, lengths come in increments of ½ in., from 2 through 6 in.; in increments of 1 from 6 in. to any length desired. Jergens Tool Specialty Co., 712 E 163 St., Cleveland 10, Ohio

For more information—
Circle 29, inside back cover

Computing Relay

A pneumatic computing relay which can be adjusted to perform any one of six different arithmetic functions is being offered. Six other relays are also available, each designed for a specific computing operation. Measurements are received by the relay as pneumatic signals (3-15 psi); computer output to a recorder or controller is also in terms of 3-15 psi. Applications are expected to include fuel-air flow

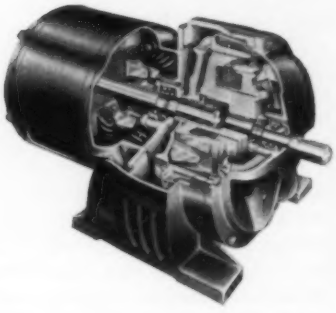
CONTINUED ON PAGE 236

EATON

DYNAMATIC®

EDDY-CURRENT EQUIPMEMT

The Most Accurate and Trouble-Free Method of Adjustable Speed Control and Testing—at Minimum Cost

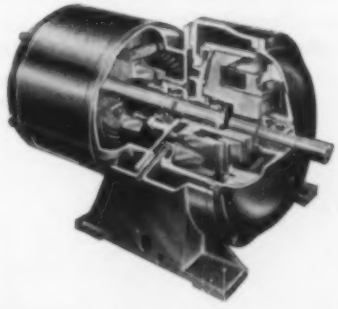


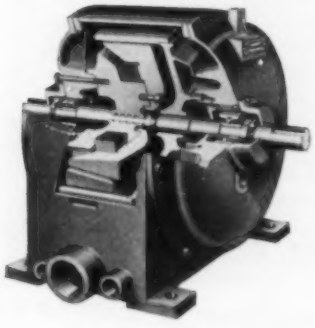
Ajusto-Spede® Drives

Dynamatic Ajusto-Spede® Drives supply infinitely adjustable speed from an AC power source—with low power losses and minimum maintenance. These air-cooled, stationary field, eddy-current couplings, integrally mounted with standard D-flange AC induction motors, provide a complete package-drive in sizes from 3 HP to 75 HP. Units of the same design and capacities are also available without motors.

Dynaspede® Drives

These Dynamatic liquid-cooled, adjustable speed, Eddy-Current Couplings, integrally mounted with standard D-flange AC induction motors provide a compact self-contained drive in sizes from 3 HP to 75 HP. Motor types available are drip proof, totally enclosed fan cooled, and explosion proof. The coupling is completely enclosed. Separately mounted couplings are also available in capacities from 3 to 2500 HP and larger.



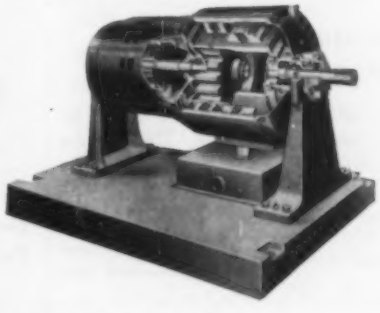


Eddy-Current Brakes

Dynamatic Eddy-Current Brakes are available in a wide range of torque capacities and operating speeds. Features include smooth, frictionless, shock-free operation with no rotating electrical components or contacts. Liquid-cooled types, as illustrated, provide loading requirements from 40 HP to 10,000 HP. Air-cooled units are available in sizes up to 50 HP.

Dynamometers

Three types of Dynamatic Eddy-Current Dynamometers are available to meet various testing requirements; absorption dynamometers up to 15,000 HP; motoring or driving dynamometers up to 500 HP; and universal dynamometers to 500 HP and larger. Special purpose dynamometers are also designed for use in applications where requirements are unusual.



Send for Illustrated Literature Covering these Dynamatic Units

EATON MANUFACTURING COMPANY — DYNAMATIC DIVISION

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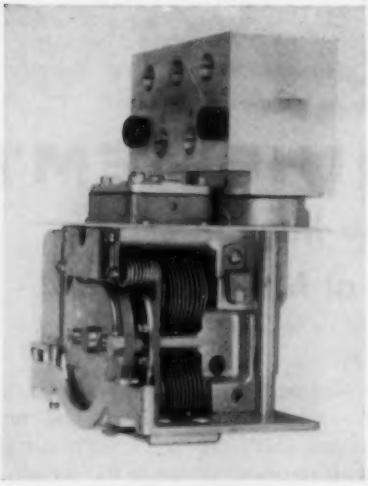


rationing, boiler swell compensation, and flow totalizing on multiple lines. Virtually any arithmetical operation, such as addition, subtraction, multiplication and division, can be accomplished. Foxboro Co., Foxboro, Mass.

For more information—
Circle 30, inside back cover

Miniature D-c Motors or Generators

Dimensions are 0.875 x 1.625 in. long; 0.098 in. shaft dia. Units longer or shorter can also be supplied. Heinz Mueller Engineering Co., 1906-08 N. Cicero Ave., Chicago 39, Ill.

For more information—
Circle 31, inside back cover

Fuseholder and Fuse

Fuseholder and fuse is designed to be used where it is desirable to have a visible or audible signal to indicate trouble on the circuit. Possible applications include many types of testing equipment, control circuits, control panels, switchboards and calculating or computing machines. Bussmann Mfg. Co., University at Jefferson, St. Louis 7, Mo.

For more information—
Circle 32, inside back cover

Adhesive Aluminum Nameplates

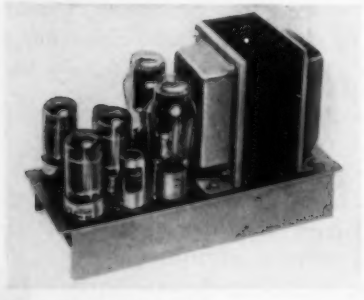
Plates with pressure-sensitive adhesive on the back which can be picked off the backing paper for application may be in one or two colors as large as 2¾ by 16 in. Topflight Corp., York, Pa.

For more information—
Circle 33, inside back cover

Modeling Plastic Compound

This is a non-drying plastic material with a putty-like consistency that can be baked in 15 min in an ordinary oven at 325-350 F. Permanently pliant before baking, it resembles hard rubber after baking, and is slightly resilient and practically unbreakable. Transogram Co., 200 Fifth Ave., New York 10, N. Y.

For more information—
Circle 34, inside back cover



Regulated D-C Power Supply

Output of the unit, 500 v d-c at 300 ma max, may be adjusted to provide any voltage between 300 and 500 v d-c by means of minor internal changes. Unit also supplies 6.3 v a-c filament voltage at 6 amp max. Regulation for a line voltage of 105 to 125 v a-c is 0.5 per cent change in output voltage; for no load to full load, output voltage change is 1 per cent. Instrument measures 12½ x 5 x 5⅜ in. above chassis and 2 in. below chassis. Weight: 23 lb. Dressen-Barnes Corp., 250 N. Vinedo Ave., Pasadena, Calif.

For more information—
Circle 35, inside back cover

Self-Sealing Bolts

These bolts are supplied as one-piece, pre-assembled units, requiring no assembly. They employ an O-ring of silicone rubber or neoprene, which is firmly held in a groove under the bolt head. They are furnished with standard hexagonal heads in a range of sizes from 10-32 up to ¼-20. Bolts can be supplied in steel, brass, corrosion-resistant steel or aluminum. Automatic & Precision Mfg. Co., 252 Hawthorne Ave., Yonkers, N. Y.

For more information—
Circle 36, inside back cover

Metal Cabinets

Selecting from 75 modular unit metal cabinet enclosures and working with 125 different sub-parts, varieties of cabinets to house instrumentation, control and electro-mechanical equipment can be produced. Available from stock are heavy-duty industrial finish writing tops, desk panels, and tops designed to protect and display memory boards or circuit diagrams. Elgin Metal Formers Corp., 630 Congdon Ave., Elgin, Ill.

For more information—
Circle 37, inside back cover

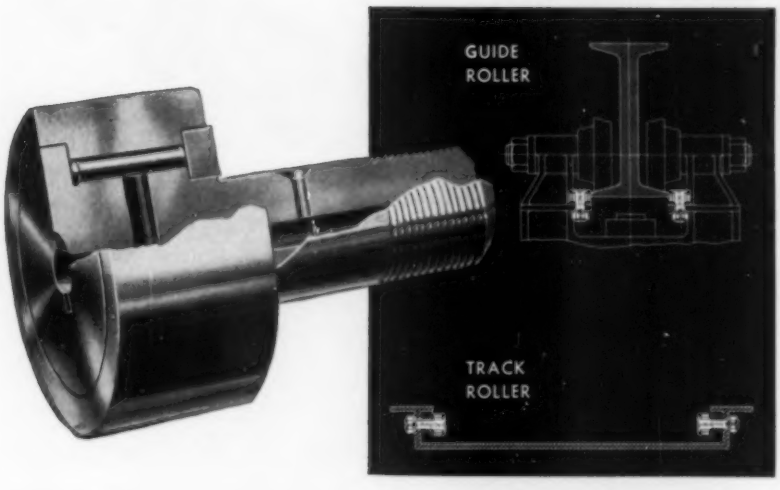
Plug-in Totalizer

This unit provides a register in programs involving velocities, pressures, temperatures, flow rates, viscosities, gages, lineal measurements, sheet countings, stacking counts, cutting counts, batchings and other processes where speeds are too great for mechanical counters. With a scale factor of from 1 to 10, maximum

CONTINUED ON PAGE 238

BEARING TIPS by McGill

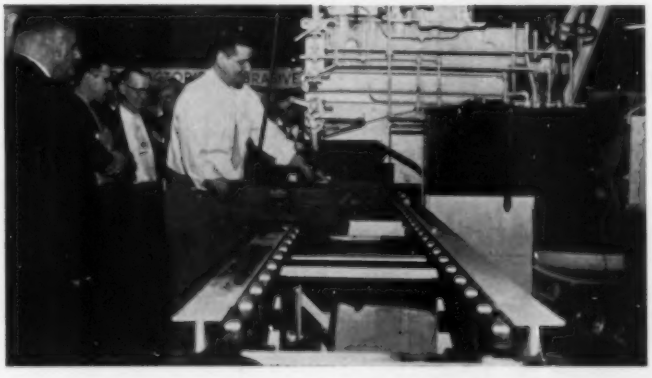
Let a CAMROL® bearing be your guide



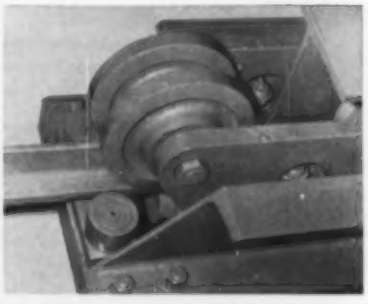
Obtain freer rolling, improved alignment and positive side thrust

In guide and support roller applications CAMROL Cam Followers insure free rolling action and positive side thrust while eliminating the wear of more costly flanged wheels. Then, too, they provide improved alignment and low starting and running friction with high unit load and shock capacity, especially at low speeds as track rollers. Lubrication is simplified and maintenance can be reduced to a minimum in these applications. Specify the interchangeable sealed SGR series for added protection against contamination.

CAMROL CF bearings provide friction-free track rollers for automatic mold blower



McGill CAMROL CF rollers are used as guide rollers to form a mold conveyor in the Beardsley & Piper MBS-20 Mold Blower. The machine blows and squeezes cope or drag in a single automatic operation, handling up to 4 molds per minute. The CAMROL CF bearings replaced less efficient friction rollers in this application. Although, the duty here is rather light and speeds slow, the cam follower bearing provides lesser starting and running friction. This helps speed the flow of work from the machine, which must be fast and automatic. The integral stud feature eases assembly and its standard design simplifies procurement.



CF bearings minimize maintenance as crane side guide rollers

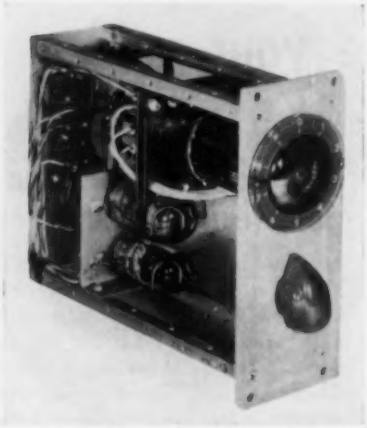
McGill CF cam follower bearings serve as side guide rollers in overhead cranes manufactured by Louden Machinery Company of Fairfield, Iowa. Freedom from maintenance, a time saver because of the inaccessibility of the bearing when the crane is in operation, is an important advantage of the cam follower bearing.

Send for Catalog No. 52-A

Insure performance with McGILL®

MULTIROL® GUIDEROL® CAMROL®
Precision Needle Bearings

McGILL MANUFACTURING COMPANY, INC., 201 N. LAFAYETTE ST., VALPARAISO, INDIANA



speed is 4 kc and resolution 250 microsec. Input requirements are: minimum amplitude of 15 v, minimum rate of rise of 1 v per microsec and minimum pulse width of 100 microsec. Input impedance is 220 k. Power requirements range from 400 v d-c at 0.5 ma to 6.3 v a-c (–125 v d-c) at 0.6 amp. Baird Associates-Atomic Instrument Co., 33 University Road, Cambridge 38, Mass.

For more information—
Circle 38, inside back cover

Transistorized Digital Counter

The unit counts articles, distance, degrees of rotation, or angular measurements. Total power consumption of the counter (2w) is no more than the filament power required by a typical tube. Transistors are said to operate well below their maximum rating. Counting frequency: 15,000 cps. Input power is 85 to 140 v, 60 cps. Resolution: 10 microsec. Size is 4 x 11⅝ x 9½ in. deep. The counter can be preset anywhere from 1 to 500 for batch counting. Nader Mfg. Co., 2661 Myrtle Ave., Monrovia, Calif.

For more information—
Circle 39, inside back cover

Molybdenum Disulfide

Incorporating molybdenum in a volatile base, this compound is applied in the same manner as a light viscosity lubricant. Vanguard Solid Lubricants, Inc., 57 E. 73 St., New York 21, N. Y.

For more information—
Circle 40, inside back cover

Transparent Labels

Printed on acetate, the labels are furnished plain or printed to provide ruled or columnar data, for use on vellum. They can be drawn, written or typewritten on. Archer Label Co., 783 Kohler St., Los Angeles 21, Calif.

For more information—
Circle 41, inside back cover

Brakemotors with Wide Torque Range

With torque range of 3 to 345 lb-ft, one-piece molded friction linings for quick stops, and one-operation torque setting, this motor is made so that operation is stopped and the load held until normal operation is restored. All types of enclosures are available including those suitable for outdoor installation or where extremely moist, corrosive, or abrasive dust conditions prevail. Reliance Electric & Mfg. Co., 1088 Ivanhoe Road, Cleveland 10, Ohio

For more information—
Circle 42, inside back cover

Switch for Two or More Circuits

A single actuator switch capable of switching two or more completely independent circuits can be double-throw, single-throw, normally open or

single throw, normally closed. Type B switches are UL-listed at 15 amp, 125 or 250 v a-c, ½ hp, 125 or 250 v a-c. Type D switches are UL-listed at 10 amp, 125 or 250 v a-c. Detroit Controls Corp., 800 Union Ave., Bridgeport, Conn.

For more information—
Circle 43, inside back cover

Pressure Transducer

A magnetic reluctance pressure transducer of the diaphragm type is now available in full-scale ranges from 1,000 to 10,000 psi. The instrument operates in recording and control systems compatible with inductance-ratio

input devices, and makes possible static and dynamic pressure measurements accurate within ±1 per cent full scale. All surfaces exposed to the working fluid are Type 416 stainless. The transducer weighs 18 oz, has a diameter of 1¾ in. Pace Engineering Co., 6914 Beck Ave., N. Hollywood, Calif.

For more information—
Circle 44, inside back cover

Synchronous Gear Motor

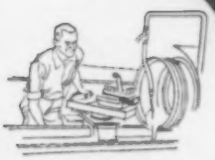
A 400 cps motor originally designed for airborne strip chart recorders and other applications is for 115 v, 100

CONTINUED ON PAGE 240

WHAT ARE AMWELD FLASH WELDED RINGS?

They are rings formed, flash butt-welded, and shaped into the finest quality circular weldments available.

They are rings that offer savings of critical materials. Bar stock formed and flash welded uses considerably less material than rings made by other methods.



They are rings that offer additional manufacturing savings. Since the rings are closer to the desired finished cross section, it is less expensive to machine them to a final dimension. Oh yes, Amweld will machine them for you.

They are rings made by a company with experience in design. We can help you select a mill-rolled or extruded shape that is even closer to the finished ring dimension. This can give you additional savings.

Yes, Amweld flash-welded rings can give you extra profit from savings on material and machining time. Amweld rings can be made of most weldable ferrous or non-ferrous metals in sizes from 4 to 96 inches.

AMERICAN WELDING

THE AMERICAN WELDING & MFG. CO. • 140 DIETZ ROAD, WARREN, OHIO

rpm service. Torque rating is 7.5 in-oz, continuous duty. Holtzer-Cabot Motor Div., National Pneumatic Co., Inc., 125 Amory St., Boston 19, Mass.

For more information—
Circle 45, inside back cover

Preset Counter

Handling from 0 to 5,000 counts per sec, the counter will operate with photo-electric, semi-conductor, magnetic, or contact making pickups. A dust-tight, oiltight (NEMA 12) enclosure is provided. Machinery Electrification, Inc., Northboro, Mass.

For more information—
Circle 46, inside back cover

Dual Relief Valves

Relief valves designed to relieve shock pressures that occur at control valves or motors are available in either guided piston or differential piston types. The units consists of two adjustable relief valves integrated into one body. Each valve relieves in one direction and can be adjusted to the same pressure or to different pressures. When oil pressure exceeds desired setting, oil is relieved from the line and directed into the other line, thereby eliminating the necessity for a connection to the system reservoir. Fluid Controls, Inc., 1284 N. Center St., Mentor, Ohio

For more information—
Circle 47, inside back cover

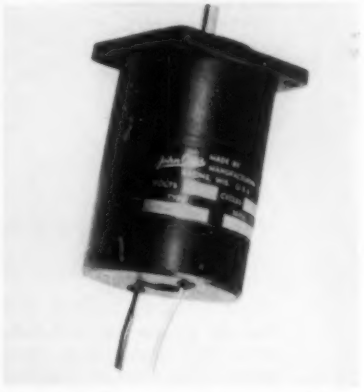
Calibrated Expansion Valve

Calibrated discs are provided on this expansion valve. These permit setting the valve opening for the rated tonnage of a cooling or freezing coil, as controlled by the pressure drop through the valve. The valve has ½ in. connections. J. E. Watkins Co., 307 Lake St., Maywood Ill.

For more information—
Circle 48, inside back cover

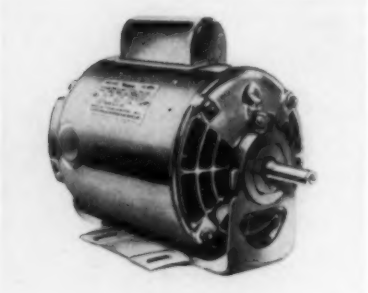
Motor-Gear Train

Overall length is 2.8 in. Output torque is 25 in-oz at 1.7 rpm, min, unloaded. Rating is for continuous duty at 115 v, 60 cps. A single-phase capacitor or two-phase servo motor with an operating temperature range from −55 C to 97 C is used. Single-phase, no-load current is 0.065 amp



max. No-load input power is 7.5 w max. Two-phase, no-load current is 0.045 amp per phase. Available with flange or other mounting types and with brake if desired. John Oster Mfg. Co., Racine, Wis.

For more information—
Circle 49, inside back cover



Fhp Motors in 48 Frames

Capacitor-start and split-phase motors in rigid and resilient base models are available in NEMA 48 frame size. Weights of ⅛, ¼ and ⅓ hp ratings have been reduced from 3 to 8 lb. Wagner Electric Corp., 6400 Plymouth Ave., St. Louis 14, Mo.

For more information—
Circle 50, inside back cover

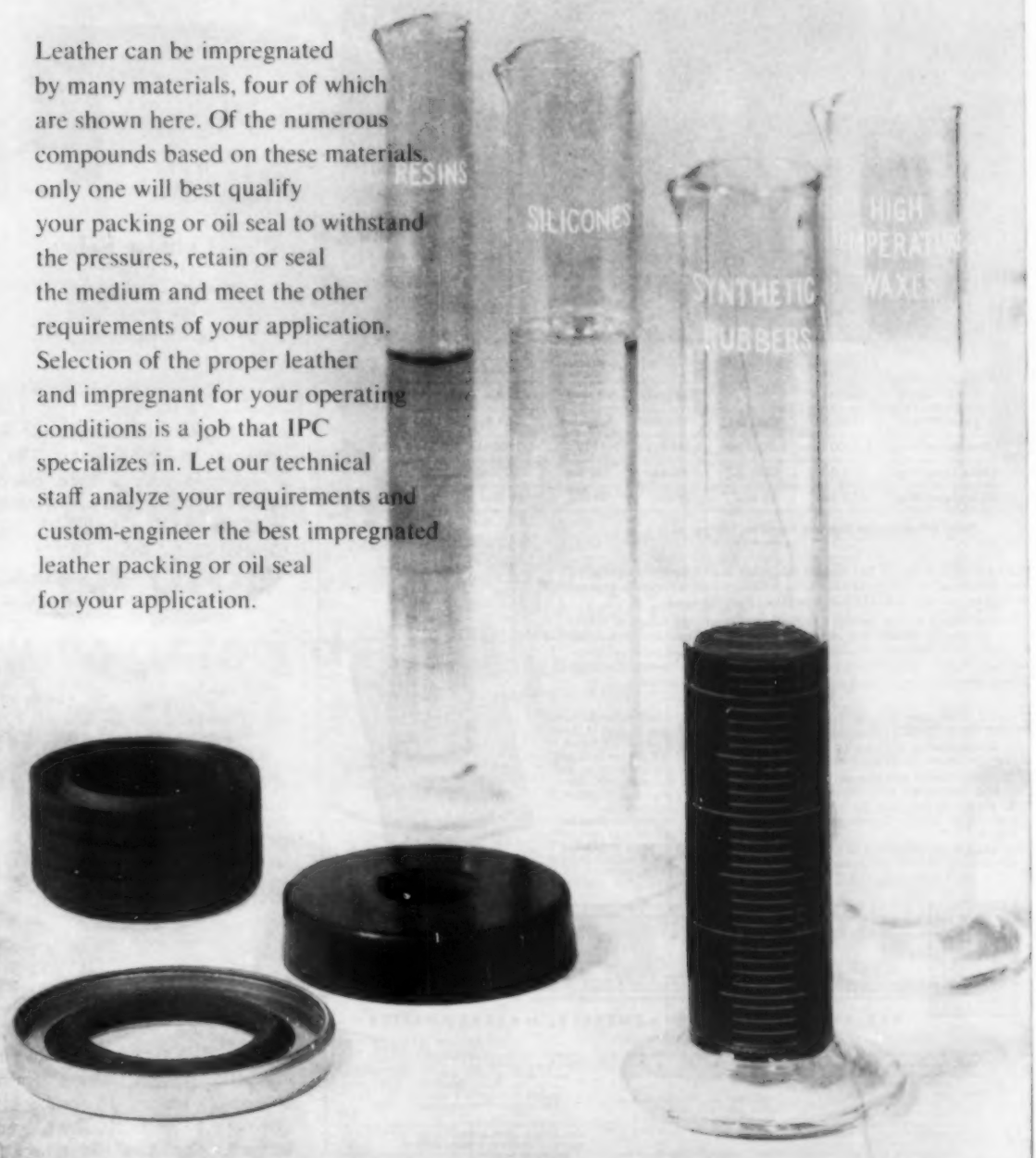
Heavy Duty Step Switch

This switch carries contact ratings of 10 amp. The rotary solenoid actuating coil operates directly on 115-v, 60-cps current without the use of rectifiers. The switch is available with 1 to 20 independent circuits. Inde-

CONTINUED ON PAGE 242

All Leather Impregnations ... but *all different*

Leather can be impregnated by many materials, four of which are shown here. Of the numerous compounds based on these materials, only one will best qualify your packing or oil seal to withstand the pressures, retain or seal the medium and meet the other requirements of your application. Selection of the proper leather and impregnant for your operating conditions is a job that IPC specializes in. Let our technical staff analyze your requirements and custom-engineer the best impregnated leather packing or oil seal for your application.



INTERNATIONAL PACKINGS CORPORATION

Bristol, New Hampshire

P1

NEW CALIDYNE model 174 SHAKER

1500 lbs. force output

a basic shaker for 6 different CALIDYNE Vibration Test Systems

SYSTEM NUMBER	1 174/203	2 174/184	3 174/80	4 174/186	5 174/186	6 174/80
Type	Sinusoidal	Sinusoidal	Sinusoidal*	Sinusoidal*	Random or Sinusoidal	Random or Sinusoidal
Power Supply	Electronic	Rotary	Electronic	Electronic	Electronic	Electronic
Force Output	1250 lbs.	1500 lbs.	1500 lbs.	1500 lbs.	1500 lbs.	1500 lbs.
Frequency Range	5-3500 cps.	5-2000 cps.	5-3500 cps.	5-3500 cps.	5-3500 cps.	5-3500 cps.
Max. Load 10 g.	105 lbs.	130 lbs.	130 lbs.	130 lbs.	130 lbs.	130 lbs.
Max. Load 20 g.	42.5 lbs.	55 lbs.	55 lbs.	55 lbs.	55 lbs.	55 lbs.

*Also adaptable for Random Vibration Testing.

CALIDYNE'S Model 174 Shaker featuring high frequency operation and low input requirements has been so designed that it can be utilized in any one of six CALIDYNE Vibration Test Systems.

The versatility of the Model 174 Shaker extends the range of vibration testing for which this shaker can be used. It further advances CALIDYNE Systems of vibration control, enabling equipment manufacturers to: create vibratory forces over a wide range, measure them, use them for testing and measuring the test results.

Typical vibration testing applications of these Model 174 CALIDYNE Shakers include:

1. **Brute force** shaking at frequencies simulating the worst conditions of ultimate operation.
2. **Structural response** to determine mode shape, frequency and damping characteristics.
3. **Fatigue testing** for high stress providing deflections many times greater than normal usage.
4. **Random** vibration testing for more exact simulation of true environment.

Complete performance data on each of these 6 CALIDYNE Series 174 Shaker Systems are contained in New Bulletin 17400. For engineering counsel in applying the destructive force of vibration to your own research and testing problems, call us here at CALIDYNE.

THE CALIDYNE COMPANY

120 CROSS STREET, WINCHESTER, MASSACHUSETTS

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NEW ENGLAND, NORTHERN NEW YORK
Technical Instruments, Inc.
Waltham, Mass. (Twinbrook 3-1400)
Syracuse, N. Y. (Syracuse 3-7870)

NEW YORK CITY, LONG ISLAND, NEW JERSEY, DELAWARE, EASTERN PENNSYLVANIA
G. Curtis Engel & Associates
Ridgewood, N. J. (Gilbert 4-0878)
Syosset, L. I., N. Y. (Walnut 1-5095)
Philadelphia, Pa. (Chestnut Hill 8-0892)

OHIO, WESTERN PENNSYLVANIA, EASTERN MICHIGAN
M. P. Odell Company
Westlake, Ohio (Trinity 1-8000)
Dayton, Ohio (Oregon 4441)
Pittsburgh, Penna. (Fremont 1-1231)
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VIRGINIA, MARYLAND, WASHINGTON, D. C.
F. R. Jodon, Inc.
Washington, D. C. (Oliver 2-4406)

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Specialized Equipment Corp.
Cocoa Beach, Fla. (Cocoa Beach 3328)

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Hugh Moreland and Co.
Chicago, Ill. (Ambassador 2-1555)
Indianapolis, Ind. (Glendale 3803)
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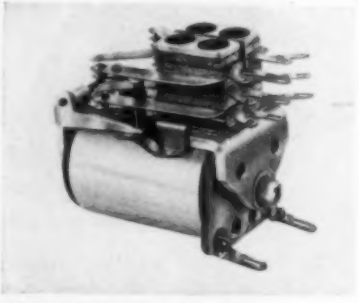
John A. Green Co.
Dallas, Texas (Riverside 3266)
Houston, Texas (Jackson 3-1021)
Tulsa, Oklahoma (Riverside 2-4657)

CALIFORNIA, ARIZONA, COLORADO, NEW MEXICO, NEVADA, OREGON, WASHINGTON, IDAHO, WESTERN MONTANA
Gerald E. Miller Co.
Hollywood, Calif. (Hollywood 2-1195)
San Diego, Calif. (Academy 2-1121)
Belmont, Calif. (Lytel 3-3438)
Tucson, Arizona (Tucson 4-4235)
Denver, Colorado (Acoma 2-9276)
Albuquerque, New Mexico (Albuquerque 5-8606)

pendent cam-operated contacts make it possible to set up any given combination or group of combinations desired for a given application. Eagle Signal Corp., Moline, Ill.

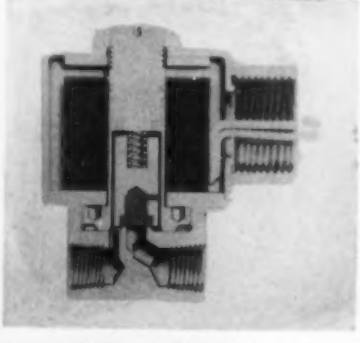
For more information—
Circle 51, inside back cover



Multi-Contact Relay

A miniature, telephone-type, multi-contact relay measures $1\frac{5}{32}$ x $\frac{23}{32}$ in. wide. Height depends on the number of springs. It is also available as a hermetically sealed unit, measuring $2\frac{1}{8}$ x $1\frac{5}{8}$ x 1 in. overall. Coil is for d-c only, single or double-wound. Resistance, up to 14,000 ohm. The relay is available with a wide choice of contact materials, and with a maximum of 18 springs (9 per pile-up). Phillips Control Corp., Joliet, Ill.

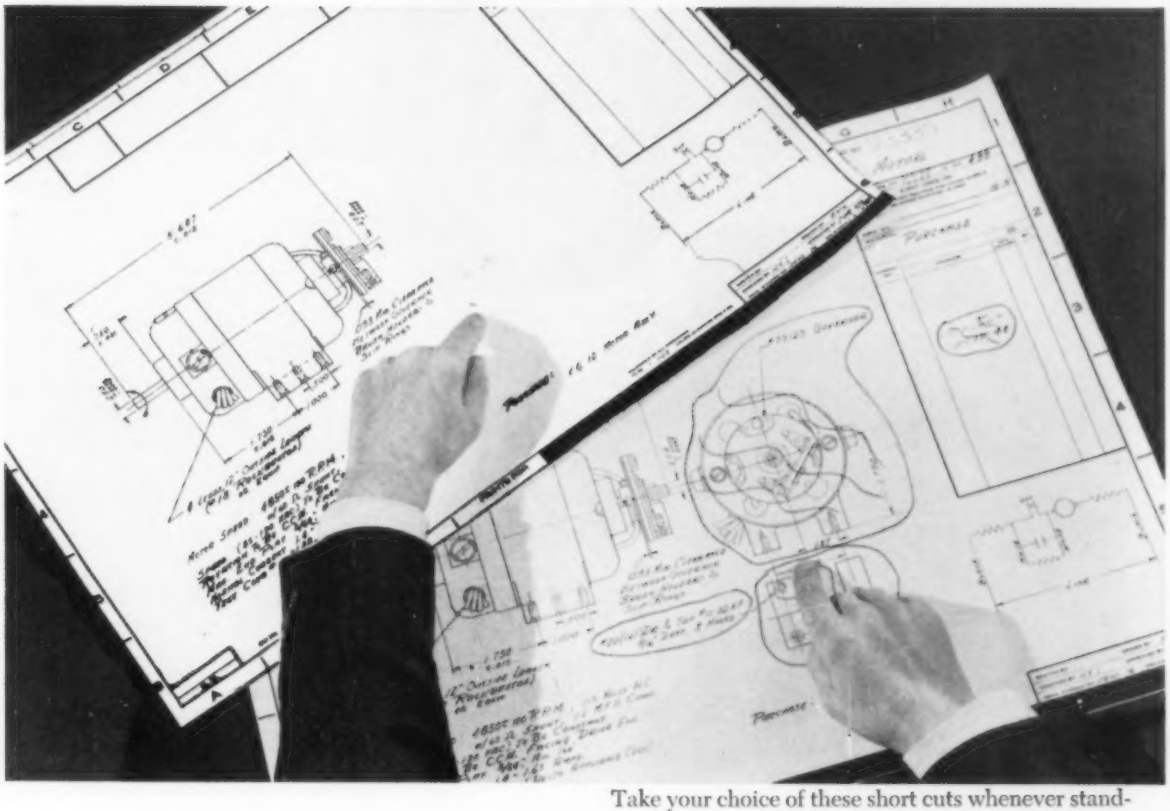
For more information—
Circle 52, inside back cover



Brass Solenoid Valve

This valve weighs 12 oz. It is packless, direct-acting, with two moving parts; positive closing is assured by a spring return. The maker claims this valve to be bubbletight, even on vacuum. The valve has orifices from $\frac{5}{32}$ to $\frac{7}{64}$ in., with pressures ranging from 60 to 130 psi. Pipe size is $\frac{1}{8}$ in.

(Continued on page 246)



2 easy ways to drop out unwanted detail

Take your choice of these short cuts whenever standard drawings must be modified . . . or parts of a design must be eliminated.

1. Reproduce the drawing on Kodagraph Autopositive Paper—you get a positive photographic intermediate directly, with dense black lines on a clean white translucent base. Scissor out the unwanted detail . . . and make another Autopositive Paper print. Lots easier than redrafting—and so is the alternate method.

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After either step, you merely add the new design . . . and your print-making "master" is ready.

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New booklet lists all the short cuts possible with Kodagraph Reproduction Materials, which you, or your local blueprinter, can process quickly, at low cost.

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TRADE MARK

GOLD N RING

Units are available in flush-plate or enclosed mountings, and are adaptable for special panel assemblies.

New...

Oil-tight • Water-tight • Dust-tight

Protected against oil and water seepage by Sealtight oil-resistant rubber diaphragm. Rated for 600 volts, AC or DC. Meets requirements of Joint Industry Committee and National Machine Tool Builders' Association.

EASILY REPLACES EXISTING SWITCHES—**Designed for mounting in 1 13/64" diameter holes on standard panel mounting centers, this switch easily replaces existing switches. Accommodates panel thicknesses of 1/16" to 1/4" in 1/32" increments. Full interchangeability of units and their components permits ready adaptation to multiple assemblies.**

Another product of...

National Acme

Sealtight CONTROL SWITCH

Made by machine tool builders to machine tool specifications

How often have you, when designing a machine tool, wished for a control station unit designed and constructed "*as a machine tool builder would build it.*"

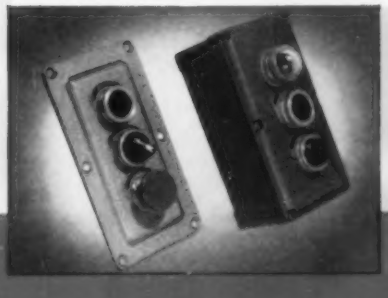
If you have been so handicapped in the past, you'll want to take a good close look at the NEW Namco GOLD-N-RING Control Station Switch Unit. Built by National Acme, builder of the world's only complete line of bar and chucking automatics, it is the *only* switch made *by* a machine tool builder *with machine tool know-how behind it.*

- **It is a heavy-duty switch in every respect.**
- **It is oil-tight, water-tight, dust-tight.**
- **Heavy-duty silver-alloy contact points provide maximum electrical capacity and long life.**
- **Heavy-duty terminal screws, with 3/8" thread contact, prevent stripping during installation and permanently secure wires for continuous trouble-free service.**
- **None easier to install; none more fool-proof.**

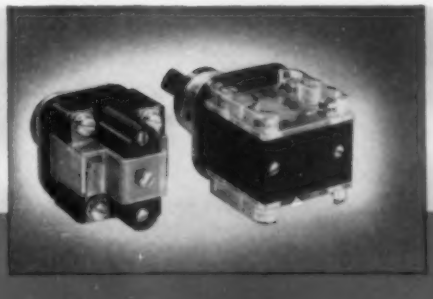
For complete details, send for Bulletin ECS-56. Better yet, ask for a representative to bring a switch for your examination.

Electrical Mfg. Division • THE NATIONAL ACME COMPANY • Cleveland 8, Ohio

▼ **FLUSH PLATES OR ENCLOSURES** accommodate any combination of individual push button, selector or pilot light assemblies. Box covers and flush plates are provided with captive screws to facilitate installation. Easy-to-read, interchangeable legend plates lock securely into position.

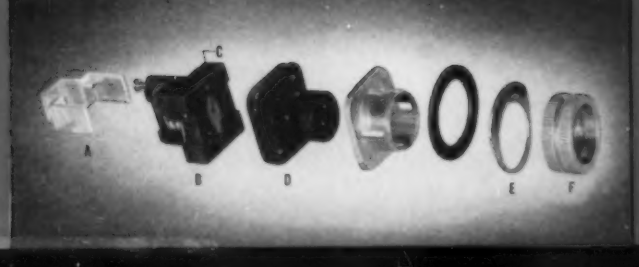


▼ **SINGLE AND DOUBLE POLE CONTACT BLOCKS** can be used interchangeably with the several types of GOLD-N-RING push button and selector operator heads. Design provides easy access for secure wiring (or use of stake-on lugs) without interference. Fixed and movable contacts are completely enclosed by heavy plastic shields.



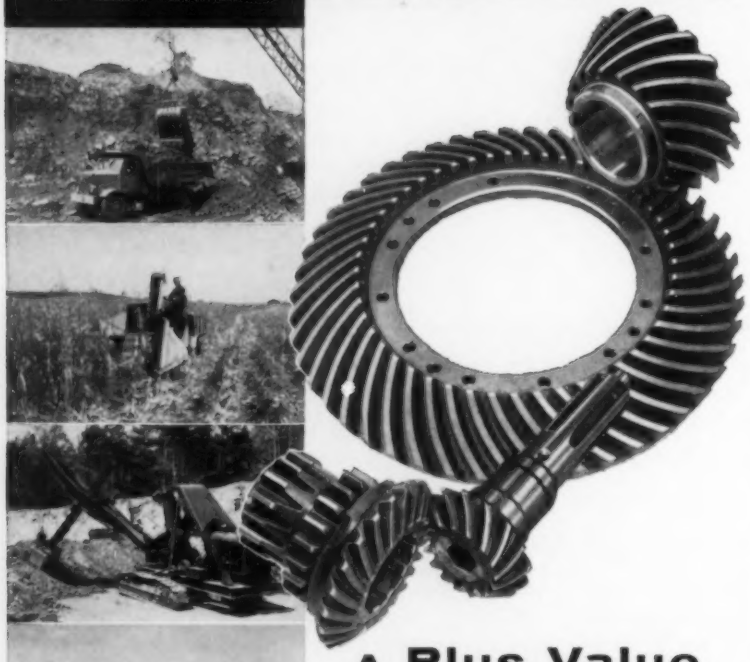
▼ **BRASS INSERTS** molded in block permanently hold stationary contacts. They also provide more thread support for the No. 8-32 terminal screws that are equipped with captive flat and lock type washers.

▼ **BUILT AS A MACHINE TOOL BUILDER WOULD BUILD IT!** Plastic shields (A) completely enclose contacts. Main block (B) is unit-molded to assure alignment and simplify assembly. Fully guided plunger (C) of cross-head design, prevents binding. Oil-resistant rubber diaphragm in operator head (D) completely seals out oil, water and dust. Easy-to-read legend plates (E) lock into position by "GOLD-N-RING" (F).



▼ **INTERCHANGEABLE "GOLD-N-RING" COLLARS** come in 3 different heights. Buttons can be made either extended or flush type merely by changing collar. Buttons are of non-fading glass-filled polyester and come in an assortment of colors to conform with standard codes.

GEARS by FAIRFIELD



A Plus Value IN ANY PRODUCT!

If GEARS are a vital part of the product you make, there is no finer recommendation for the QUALITY of your product than to be able to say it is equipped with "FAIRFIELD GEARS."

Long producers of the gears needed in high grade trucks and tractors, Fairfield now brings the same standards for GEAR PERFORMANCE to a wide variety of products: Agricultural Implements . . . Power Shovels . . . Machine Tools . . . Diesel Locomotives . . . Road Graders . . . Lift Trucks . . . Road Rollers . . . Pump Drives . . . Winches . . . Military Vehicles . . . and a host of others.

Fairfield's facilities are unexcelled. Here "under one roof" in a new and ultra modern plant, Fairfield has everything needed for producing all kinds of gears: spur . . . herringbone . . . spiral bevel . . . ground tooth spiral bevel . . . straight bevel . . . coniflex bevel . . . hypoid . . . zerol . . . worms and worm gears . . . splined shafts . . . differentials. Get acquainted with Fairfield — your inquiry will receive prompt attention.

Send for illustrated bulletin describing Fairfield's facilities.

FAIRFIELD
MANUFACTURING CO.
2305 S. Concord Rd.,
Lafayette, Indiana

For FINE GEARS

NPT. Skinner Electric Valve Div., Skinner Chuck Co., New Britain, Conn.

For more information—
Circle 53, inside back cover

Flange Union For High Pressures

The union will withstand operating pressures to 3,000 psi for Schedule 80 pipe and special unions incorporating the same design can be provided to withstand pressures up to 10,000 psi. This union is available for pipe sizes ranging from $\frac{1}{8}$ to 6 in. Almar Hydraulic Valve Co., 10011 Meech Ave., Cleveland 5, Ohio

For more information—
Circle 54, inside back cover

Servo Actuator

This permanent magnet-type rotary servo actuator was originally designed for airborne applications. It can take continuous operation at an output rating of 70 in-lb at 8.5 rpm. Theoretical acceleration at stall is 40,000 radian/sec^2 and dynamic motor braking is incorporated. The unit weighs 1.9 lb, diameter is $3\frac{7}{16}$ in. and length $4\frac{7}{8}$ in., including the AN connector. White-Rogers Co., 4407 Cook St., St. Louis 13, Mo.

For more information—
Circle 55, inside back cover

Motor for Timing Units

A synchronous motor designed for incorporation in timers subjected to

(Continued on page 249)

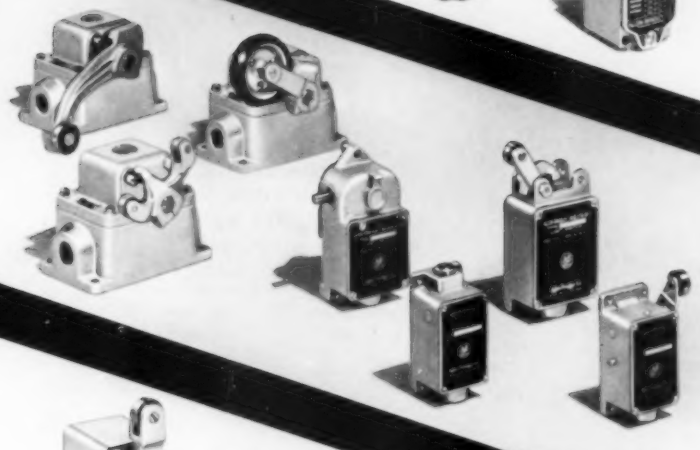
Need a Limit Switch?

WHAT'LL YOU HAVE?

Here are samples of A-B quality limit switches—a line so complete it will satisfy your every requirement!

OILTIGHT

Bulletin 802T—For high-speed production machines. Sealed to protect the switch against oil and coolants.



GENERAL PURPOSE

Bulletin 801—Standard or heavy-duty rating, with roller, push type, or fork lever action, and slow or snap action contacts.

Bulletin 803 Cam Limit Switch used on rotating machines to open and close circuits at any desired angular position.

PRECISION

Bulletin 802—For applications where mounting space is small and operating motion is measured in thousandths of an inch.

1-57-MR

ALLEN-BRADLEY

QUALITY

MOTOR CONTROL

A-B Quality

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis. • In Canada—Allen-Bradley Canada Ltd., Galt, Ont.

PILOT CONTROLS?

Yes...Allen-Bradley covers the field!

No matter what your needs for pilot control devices may be . . . refer to the new Allen-Bradley "handy" catalog . . . you will usually find what you are looking for. If not, please write Milwaukee, or contact your nearest Allen-Bradley representative.

All pilot controls are made to Allen-Bradley standards of quality. All of them have silver alloy contacts that require no service attention. You'll find it saves service time and money to specify Allen-Bradley.

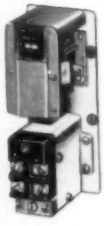
PHASE FAILURE AND PHASE REVERSAL RELAYS
BULLETIN 812
Style A disconnects motor if one phase of power circuit fails. Style B protects against phase reversal, as well.

OILTIGHT PUSH BUTTON STATIONS
BULLETIN 800T
For machine tool applications, to keep oil away from the contacts. Available in flush, surface, or pendant mounting.

PRESSURE CONTROLS
BULLETIN 836
For noncorrosive liquids, vapors, gases, from 30 in. of vacuum to 700 psi. Accurate, rugged, compact, and attractive appearing.

PLUGGING SWITCHES
BULLETIN 808P
Used with a simple reversing switch, it provides quick, automatic stopping of machines driven by squirrel cage motors.

TIMING RELAYS
BULLETIN 849
A reliable and accurate pneumatic timer with a range of 1/6 to 180 seconds. Many arrangements. Motor driven, electronic and oil dashpot timers also available.



TEMPERATURE CONTROLS
BULLETIN 837
For temperatures from −45°F to 440°F. Metal bellows operates snap action precision switch with pure silver contacts.

FOOT SWITCHES
BULLETIN 805
For operating punch presses, riveting, welding, and many other machines. Switch has snap acting, normally open and normally closed silver alloy contacts.

ZERO SPEED SWITCHES
BULLETIN 808
A plugging switch that brings squirrel cage motors to zero speed quickly, without any reversal of direction.

FLOAT SWITCHES
BULLETIN 840
Provide automatic control for motors operating tank or sump pumps.

PRESSURE SWITCHES
BULLETIN 830
For domestic water pumps, and commercial and industrial air compressors.

ROTARY SWITCHES
BULLETIN 806
Cam operated switches for the selection or transfer of various control circuits. Silver alloy contacts.

1-57-MR

A-B Quality

ALLEN-BRADLEY

MOTOR CONTROL

QUALITY

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
In Canada—Allen-Bradley Canada Ltd., Galt, Ont.

Send for the new 7th Edition of the Allen-Bradley Handy Catalog. It is a veritable encyclopedia of reliable motor control.

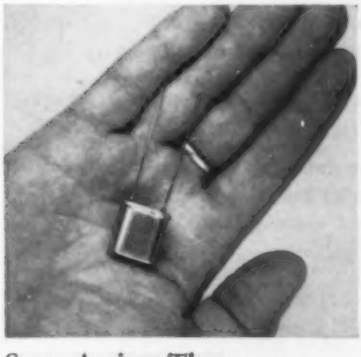
temperatures up to 150 F has its first pinion cut integrally with the motor shaft, eliminating pinion rattle. This design also makes possible a small pitch diameter, which permits a low fpm speed and a slower speed of the gear reduction unit. Lux Clock Mfg. Co., 95 Johnson St., Waterbury, Conn.

For more information—
Circle 56, inside back cover

Steam Trap

This steam trap is for a wide range of applications requiring high discharge capacity at pressures up to 25 psi. The unit fits into existing piping layouts by virtue of its dual inlets and outlets, which permit universal installation. Available for ¾ and 1 in. lines. W. H. Nicholson & Co., Wilkes-Barre, Pa.

For more information—
Circle 57, inside back cover



Snap-Acting Thermostat

This snap-acting, disc-type thermostat is for applications where maximum shock and vibration resistance are required. Fine silver electric contacts and a completely sealed assembly are provided. A copper-nickel plated

(Continued on page 253)

Felt can be made "TOUGH AS NAILS"

. . . or soft as a cotton ball! The range of densities and the surfaces and finishes you can get with Felt by Felters are truly amazing!

Measured in pounds per square yard, felt goes all the way from 0.81 lbs. for ⅛" to 8.4 lbs. for ½", with greater ranges on special order. The hard, rough, hornlike fibres form an excellent material for glass polishing and give exceptional wearing qualities when in contact with moving machinery parts. And fine, sanded surfaces are ideal for lubricating and filtering.

FELT IN USE . . . This manufacturer uses felt strips for buffing guides in their cylinder hones. Felt wears at same rate as stones to provide good bearing and cutting guide.

Send for FELTERS Design Book

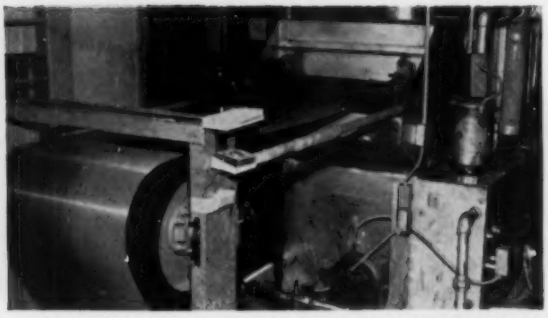
20 pages of "Facts" on how you can use the unique properties of felt. It's yours for the asking, sent to help you build a better product. Send for it today: The Felters Company, 228 South Street, Boston 11, Mass.

Get the Best, Specify

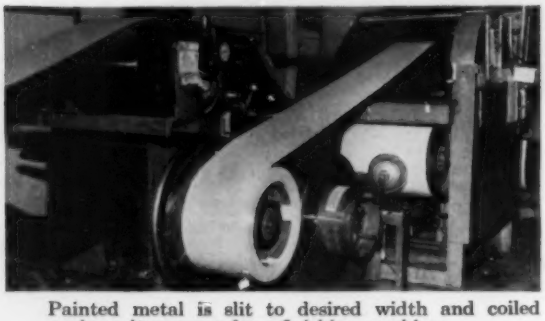
Felt by Felters

FES-26

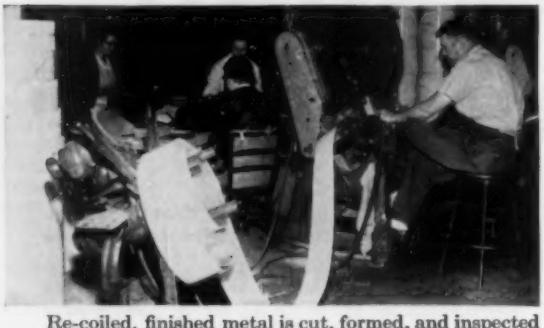
228 South St., Boston 11, Mass. *Manufacturers of Felt and Felt Products*



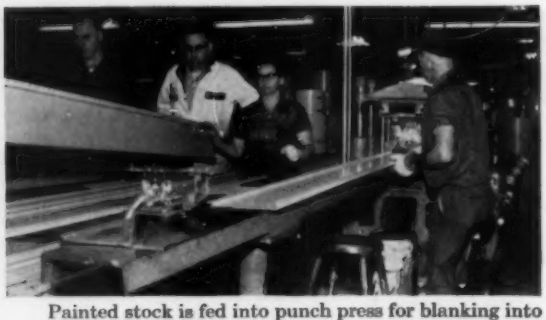
Strip is re-coiled after its treatment with Bonderite, corrosion resistant paint bond.



Painted metal is slit to desired width and coiled again as it emerges from finishing machine.



Re-coiled, finished metal is cut, formed, and inspected here. No loss of paint adhesion.



Painted stock is fed into punch press for blanking into various shapes and sizes.

Photos courtesy Hastings Aluminum Products, Inc.

Bonderized... Painted... Formed...

NO LOSS OF PAINT ADHESION!

Here's a production wrinkle that more and more manufacturers are using: Finish metal in the strip, then fabricate the product.

The technique applies equally well on steel and aluminum. First, run the strip through the Bonderite machine to produce the phosphate integral surface that supplies a secure anchor for the paint. Next, run the Bonderized strip through roll-coat painting and the bake oven. The painted coils of metal are ready for fabrication, and the finish doesn't crack, chip or craze as it is formed, drilled, and punched.

Fabrication after painting, made possible by Bonderizing, saves money by reducing labor, handling and manufacturing area requirements, and allows higher production rates.

Write or call for more information on how you can finish before fabrication in your plant.

Bonderite, Bonderizing, Bonderized—Reg. U.S. Pat. Off.

PARKER RUST PROOF COMPANY
2179 E. MILWAUKEE, DETROIT 11, MICHIGAN

Since 1914— leader in the field

BONDERITE	BONDERITE and BONDERLUBE	PARCO COMPOUND	PARCO LUBRITE	TROPICAL
corrosion resistant paint base	aids in cold forming of metals	rust resistant	wear resistant for friction surfaces	heavy duty maintenance paints since 1883

Here is an entirely new series of clutches combining, in a single compact unit, all of the PROVED advantages of MAXITORQ Floating Disc Clutch design with an exceptionally simple, powerful, and dependable electro-magnetic actuating mechanism.

As will be seen from the illustration, the new clutches use standard proved MAXITORQ Disc-Pacs, quickly and easily replaced. The electro-magnetic unit is enclosed in a stationary housing, permitting direct wiring connection. When energized, the magnetic coil acts through an armature plate and sleeve to exert pressure on the clutch discs. Pressure, however, is maintained entirely by the magnetic flux, without mechanical contact between moving and stationary parts.

This unique design permits instant, positive engagement or disengagement, with the additional possibility of precisely controlling torque for a gradual pick-up or release of load. In addition to meeting standard clutch and brake installation requirements, MAXITORQ Electric Clutches open up new possibilities in application to fully automated equipment and for remote control.

Standard sizes, both single and double types, for wet or dry operation, are available with up to 788 ft. lbs. torque, and operate on 110V-AC rectified to 90V-DC.

Complete details sent on request. Write Dept. PE-1.

- **PROVED** performance.
- **COMPACT** design.
- **FLOATING** neutral . . . no drag.
- **POSITIVE** engagement.
- **STATIONARY** coil . . . no brushes.
- **NO ADJUSTMENT.**
- **WET OR DRY** operation.
- **FULL** power transmission.
- **FULL** range of sizes, types.

THE CARLYLE JOHNSON MACHINE COMPANY

MANCHESTER, CONNECTICUT

6CJ56

How R/M FLEXIBLE THIN-WALL Teflon* HOSE can help you solve difficult design problems

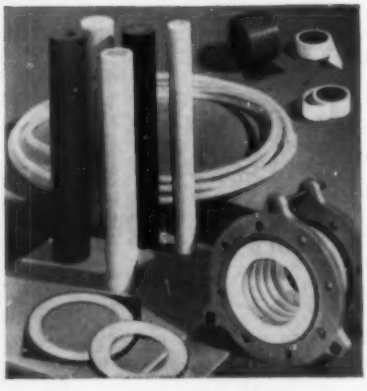
Wherever extreme ambient temperatures and corrosion are problems, your best solution is R/M Flexible Thin-Wall "Teflon" Hose. It can be depended on to retain its flexibility and toughness from −100° to +400°F and it is completely impervious to the corrosive action of all types of acids, caustics and solvents. It does not expand, contract or fatigue. Storable indefinitely without deterioration.

R/M can furnish this hose in both stainless steel wire-braided and rubber-covered forms.

This contribution to better performance and greater safety is the result of R/M's long experience with "Teflon." Ever since it first came into use, our laboratories have been developing the vast potentialities of this material for all phases of industry. Write today for complete information.

R/M's complete line of "Teflon" products includes: rods, sheets, tubes and tape; centerless ground rods held to very close tolerances; stress-relieved molded rods and tubes; gaskets; expansion joints and flexible couplings; Bondable "Teflon"; braided metal and rubber-covered flexible hose; Raylon—R/M trade name for mechanical grade "Teflon"—having many characteristics of virgin "Teflon." Write for complete data.

*A Du Pont trademark



R/M

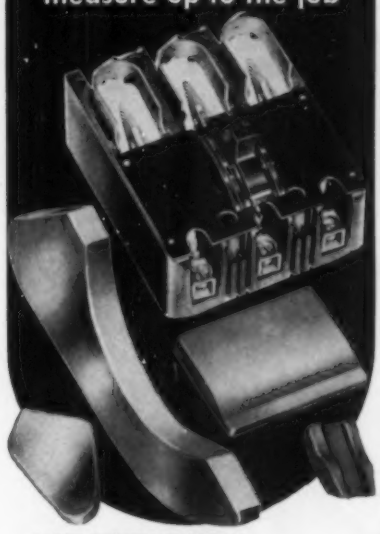
RAYBESTOS-MANHATTAN, INC.

PLASTIC PRODUCTS DIVISION, MANHEIM, PA.

FACTORIES: Manheim, Pa.; Bridgeport, Conn.; No. Charleston, S.C.; Passaic, N.J.; Neenah, Wis.; Crawfordsville, Ind.; Peterborough, Ontario, Canada

RAYBESTOS-MANHATTAN, INC., Engineered Plastics • Asbestos Textiles • Mechanical Packings • Industrial Rubber • Sintered Metal Products • Rubber Covered Equipment
Abrasive and Diamond Wheels • Brake Linings • Brake Blocks • Clutch Facings • Laundry Pads and Covers • Industrial Adhesives • Bowling Balls

Gibsiloy
SILVER-TUNGSTEN CONTACTS
measure up to the job



• **FOR CIRCUIT BREAKERS**
The rigid requirements of circuit breakers — compact design, low temperature rise, high interrupting capacity — demand Gibsiloy silver-tungsten electrical contacts.

• **RIGHT PROPERTIES**
These Gibsiloys have low contact resistance, high current-interrupting capacity, non-welding and other properties which mean trouble-free breaker operation.

• **FLEXIBILITY**
Gibson's large range of silver-tungsten metal combinations and forms—plus our engineering skill in adapting the right contact to your product—can be a vital asset to you.

• **SERVICE**
Contacts are our business. Our round-the-clock production devoted to this one field means quick delivery of quality contacts. Let us know your needs.

Gibsiloy
ELECTRICAL CONTACTS
Manufactured by
GIBSON ELECTRIC COMPANY
8358 Frankstown Ave. Pittsburgh 21, Pa.

steel casing protects all parts from contamination and moisture to assure precise circuit operation. Standard temperature settings, which are fixed, range from −20 F to 400 F. Spencer Thermostat Div., Metals & Controls Corp., Attleboro, Mass.

For more information—
Circle 58, iside back cover

Linear Scale Ammeters

The standard model is designed for use on a 200 or 115-v, three-phase, 400-cps system. It is supplied with a special transformer that converts a-c current to the 5-milliamp level. Standard specifications include accuracy of 2 per cent, a volt-ampere consumption of less than 0.05 va at full-scale deflection, a breakdown potential of 2,000 v and an overload capacity up to 300 per cent. The meter range is from 0 to 115 amp. Beckman Helipot Corporation, Newport Beach, Calif.

For more information—
Circle 59, inside back cover

Subminiature Wire-wound Potentiometers

With resistance range from 10 ohm to 250 k and linearity of 0.3 per cent, these units are ½ x ½ in. Weight is ¼ oz, power 2 w for 60 C rise. Ace Electronics Associates, Inc., 103 Dover St., Somerville 44, Mass.

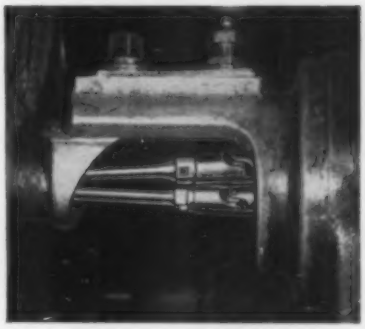
For more information—
Circle 60, inside back cover

High Deflection Hangers

A line of steel spring hangers, for suspending disturbance-generating equipment and piping systems, and

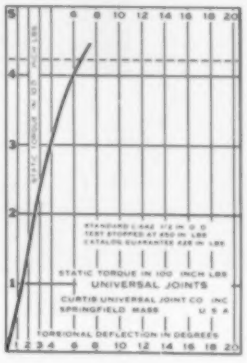
(Continued on page 256)

Solving a breakage problem AT CLOSE QUARTERS



The manufacturer of this button-drilling machine had a tough problem: the universal joints on these parallel shafts carried such a torque load there were frequent complaints of breakage . . . yet the close centers prohibited use of a larger joint.

THE SOLUTION was a Curtis Universal Joint of the same size.


STATIC TORQUE IN 100 INCH LBS
UNIVERSAL JOINTS
CURTIS UNIVERSAL JOINT CO. INC
SPRINGFIELD MASS U S A
TORSIONAL DEFLECTION IN DEGREES

Torque Curve ½" Curtis Universal Joint

This is only one of many problems solved by Curtis Joints — size for size the strongest universal joints designed for industry. Selected materials, precision engineering, and over 30 years' experience manufacturing universal joints make them that way.

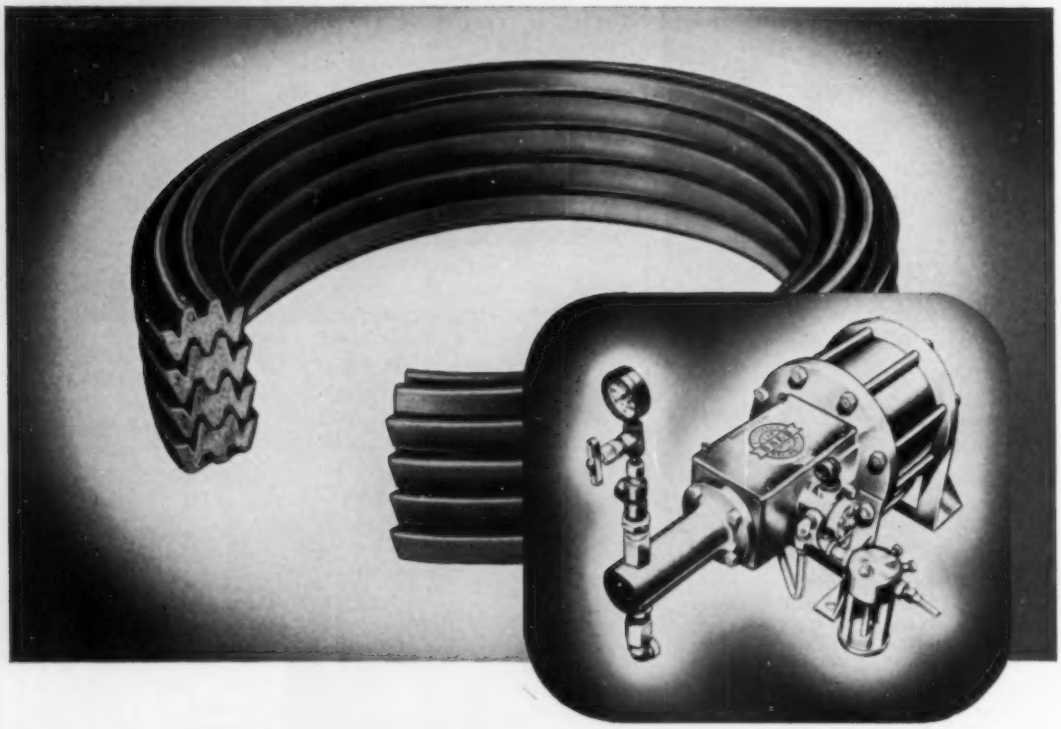
14 SIZES ALWAYS IN STOCK —
⅜" to 4" O.D. (6" joints on special order)

Not sold through distributors. Write direct for free engineering data and price list.

TRADE MARK CURTIS
UNIVERSAL JOINT CO., INC.
11 Birnie Avenue, Springfield, Mass.
As near to you as your telephone

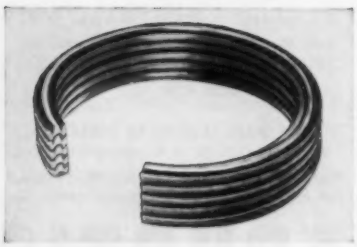
EXCLUSIVELY A MANUFACTURER OF UNIVERSAL JOINTS SINCE 1919

J-M Uneepac® does it again!



"Very satisfactory sealing service against wide variety of fluids and pressures up to 5,500 psi"

says Black, Sivalls and Bryson, Inc. makers of BS&B Glycol Pump



Uneepac comes in two types. Shown here is design for flange widths up to ½" which is used in BS&B Glycol Pump. Large illustration above shows design for flange widths over ½".

Chalk up another success story for Uneepac—Johns-Manville's automatic ring packing. In the BS&B Glycol Pump, fluids handled include triethylene glycol, diethylene glycol, gasoline, and various types of oils, alcohols and petroleum treating chemicals. Working pressures range from 125 psi to 5,500 psi with average operating pressures at 3,000 psi. Yet despite these rugged service conditions, Uneepac has delivered—in Black, Sivalls and Bryson's own words—"very satisfactory service."

Many other packing users have acclaimed J-M Uneepac for its long, trouble-free service. Each ring is a complete packing unit. Fewer rings are needed than ordinarily required and stuffing box size can be reduced to the minimum. Each ring centers itself automatically on the preceding ring to simplify installation. This exclusive design also permits fluid pressure to act upon each lip individually and protects lips from excessive gland pressure.

J-M Uneepac comes in a wide range of styles and sizes for many rod and plunger applications. For further information write Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ontario.

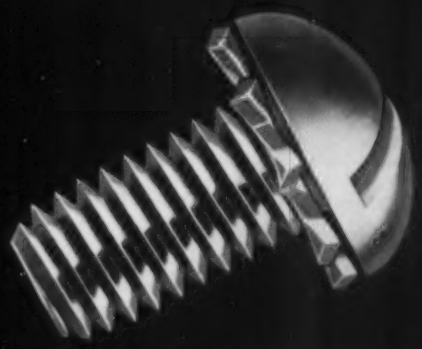
Johns-Manville PACKINGS, GASKETS and TEXTILES

Pre-assembled

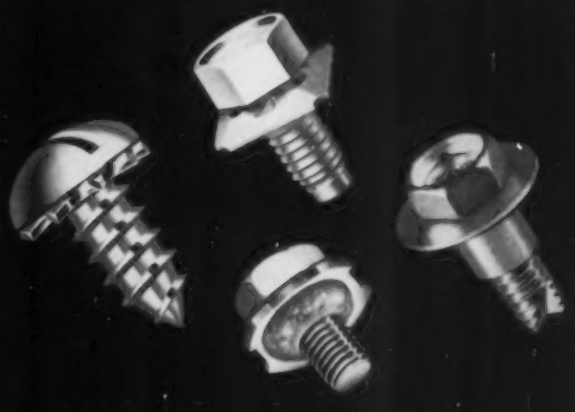
to cut your

Costs

...by eliminating handling of multiple parts



SEMS-BY-SHAKEPROOF
Pre-assembled Screw
and Shakeproof® Lock Washer



Even greater cost-savings are possible with Sems-by-Shakeproof through variations in threads, points, heads, and washers, or with the addition of sealing compound or special sleeves.

• You handle one unit instead of two or more with Sems-by-Shakeproof • Every lock washer is factory-matched • Lost and forgotten washers eliminated • Available in variety of screw and lock washer combinations, multiple-piece assemblies and with mastic sealants.

Send for Sems-by-Shakeproof sample kit today

SHAKEPROOF

"FASTENING HEADQUARTERS"®

DIVISION OF ILLINOIS TOOL WORKS

St. Charles Road, Elgin, Illinois • Offices In Principal Cities
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itw

for YOUR product...

the RIGHT sealer!

the RIGHT shape!

Presstite-Keystone manufactures over 400 sealants
—in all sizes and shapes... with all kinds of characteristics for all kinds of applications for product improvement. Presstite Sealing Compounds seal in quality by sealing out water, moisture, dust or air—engineered to individual needs.

THIS SERVICE IS YOURS—AT NO COST!

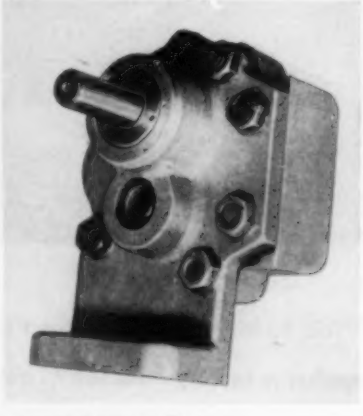
Chances are, the sealant YOU need is among the more than 400 products already available. Describe your needs, include a sketch, if possible, of the area of application and desired characteristics. Our Engineering Dept. will gladly make suggestions.

PRESSTITE SEALING COMPOUNDS
PRESSTITE-KEYSTONE ENGINEERING PRODUCTS COMPANY
K A P

A Division of AMERICAN-MARIETTA COMPANY
3750 CHOUTEAU AVENUE, ST. LOUIS 10, MISSOURI

providing maximum freedom from vibration transmission are supplied in a box-type, U-bracket, or without any housing. Effective load range is from 50 to 3800 lb. Korfund Co., Inc., 48-19C 32 Pl., Long Island City 1, N. Y.

For more information—
Circle 61, inside back cover



Gear Pump For Up to 200 Psi

This pump can be adapted to engine oil pumps, fuel injection systems, automatic transmissions, oil burners, machine tool mechanisms. A molded synthetic rubber element conforms with zero clearance to the gear teeth along the pressure outlet side of the pump. A calibrated spring controls the action of the tip clearance pad. In effect, it serves as a pressure relief valve, calibrated to cut off at an established maximum pressure value, permitting the tip clearance pad to

(Continued on page 261)

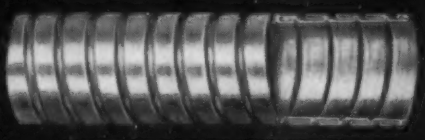
EXTRA HEAVY DUTY

HEAVY DUTY

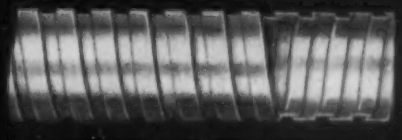
LIGHT DUTY

MEDIUM DUTY

PENFLEX



LIGHTWEIGHT EXHAUST



SQUARE LOCKED CASING

RUGGED FLEXIBILITY

FOR EVERY INDUSTRY'S REQUIREMENTS

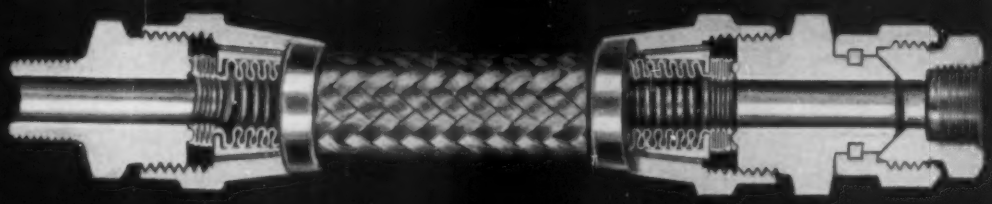
Tough as a pipe, but flexible, that is Penflex tubing. You name your need for conveying volatiles, liquids, chemicals, powders, granular materials, or semi-solids . . . hot or cold . . . and Penflex has the right tubing to provide the maximum service. It is unsurpassed for withstanding rough abuse, abrasion, crushing and heat.

Squarelocked, interlocked, corrugated . . . packed or unpacked . . . braided or unbraided . . . with all types of couplings. Penflex makes them to meet your exact specifications and scientifically engineers them to the installation with "Flexineering." If you need flexible metal tubing from 1/8" to 24" I.D. . . . bronze, galvanized or stainless steel call on your Penflex man. For data on the complete line of products . . . plus valuable specifications on flexible tubing write for your copy of "Flexineering."

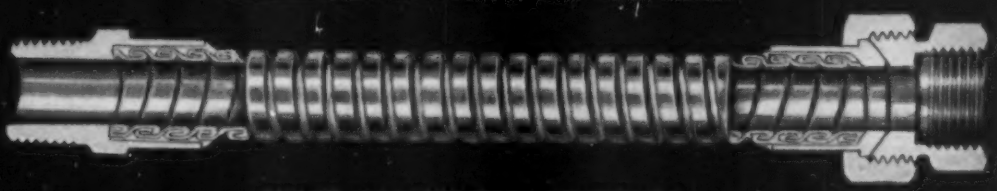
PENNSYLVANIA FLEXIBLE METALLIC TUBING COMPANY, INC.

7240 POWERS LANE, PHILADELPHIA 42, PA.

Branch Sales Offices: **Boston New York Chicago Houston Cleveland Los Angeles**
and Distributors in Principal Cities



PENFLEXWELD WITH HEATPROOF COUPLINGS



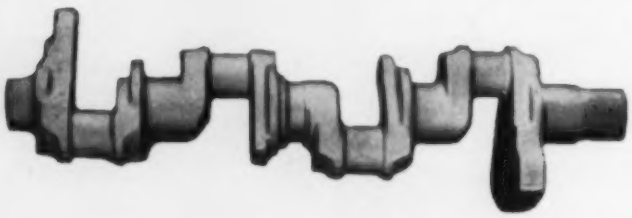
M-100 WITH SOLDERED COUPLINGS

whether you think in terms of

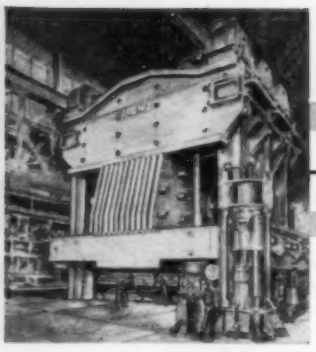
Horsepower

— or —

Thrust



The crankshaft is the backbone of the piston-type engine. Illustrated above is the crankshaft forging for the most powerful piston-type aircraft engine ever produced.



The history of Wyman-Gordon's contribution to aircraft progress dates from the inception of the "flying machine". The jet age is now calling on the unparalleled resources of Wyman-Gordon, which include the widest range of hammer and press equipment and the greatest technical know-how in the industry. Larger and more intricate forgings than heretofore available of aluminum and magnesium are being produced on presses up to 50,000 ton capacity, and giant hammers are fulfilling the growing need for forgings of titanium, high density materials or so-called super alloys. Now, as for nearly 75 years, there is no substitute for Wyman-Gordon experience and ability for — Keeping Ahead of Progress.

At the bottom left is a turbine disc forging made from high density heat resisting alloy, and next to it is a titanium compressor wheel forging for two of the most powerful jet engines yet produced.

WYMAN-GORDON COMPANY

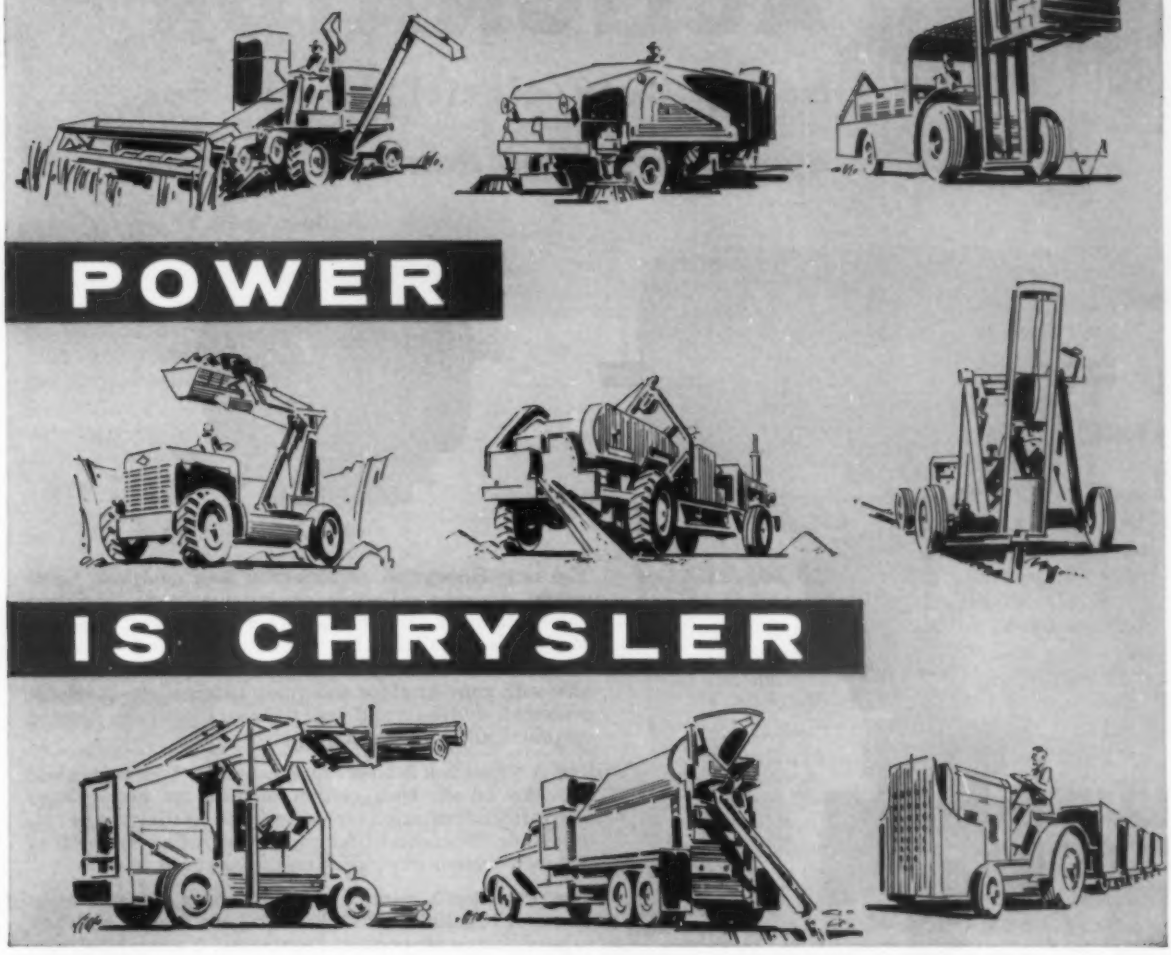
Established 1883

FORGINGS OF ALUMINUM • MAGNESIUM • STEEL • TITANIUM

WORCESTER 1, MASSACHUSETTS

HARVEY, ILLINOIS • DETROIT, MICHIGAN

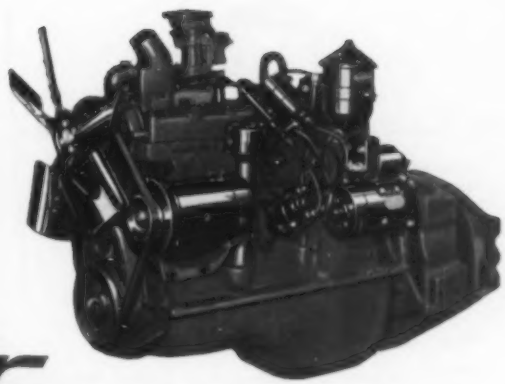
THE PAYOFF POWER IS CHRYSLER



In the oilfields of Texas and Oklahoma . . . in the timber country . . . farmlands . . . industrial areas . . . and on construction jobs large and small. Wherever big shouldered, hard driving power is required – there you'll find Chrysler Industrial Engines at work.

Look around. More and more manufacturers are powering with Chrysler when they build. More and more users are specifying Chrysler Power when they buy. Why? Because both have found that Chrysler produces more payoff power than any other industrial engine built today.

See a Chrysler Industrial Engine Dealer – listed in the yellow pages of your telephone book – or write for detailed information: **Dept. B-1, Industrial Engine Division, Chrysler Corporation, Detroit 31, Michigan.**



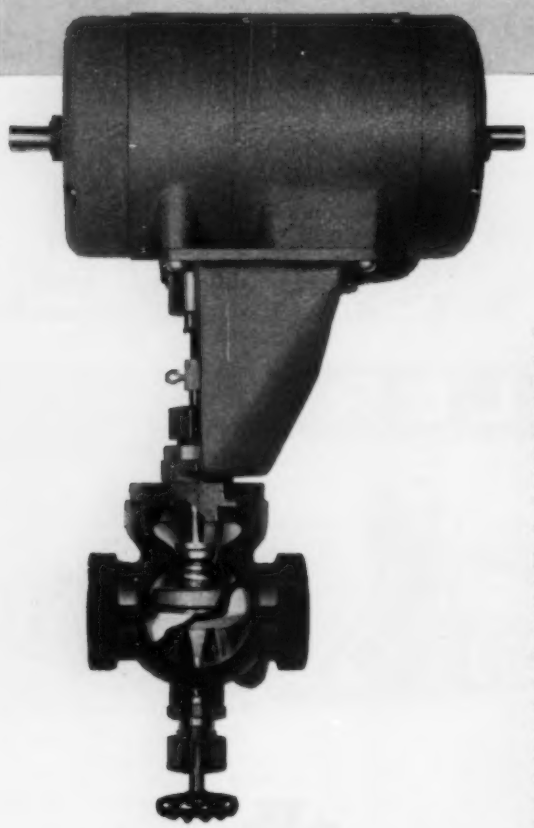
Chrysler

INDUSTRIAL ENGINES

INDUSTRIAL ENGINE DIVISION • CHRYSLER CORPORATION

NEW ACTIONATOR*

heavy duty electric motor for operating valves, dampers, louvers



The new Honeywell ACTIONATOR is a compact, lightweight, rugged and flexible industrial motor for operating valves, dampers, louvers, and other final control elements. Models are available for mounting on, and operating rotary valves or dampers. The ACTIONATOR is also available with cam operator and yoke. Internal strain release protects valve seats and gear train so that it can be used on practically any slip stem valve.

The ACTIONATOR is a reversing capacitor type motor and provides on-off, two-position, floating or proportional control. Shaft rotation can cover up to 180 degrees in 7½, 30, 60, or 120 second timings; torque ratings from 50 to 200 inch-pounds depending on motor speed.

The proportional control model provides slidewire resistances of 100, 135 or 1000 ohms, and can be used with any type of electric proportional controller. A second slidewire can be used for retransmission . . . to operate another motor, or for remote indication. Spst and spdt auxiliary switches can also be installed within the end bells. The enclosed terminal compartment is designed to meet J.I.C. standards.

Limit and auxiliary switches, specially designed by MICRO SWITCH, allow the ACTIONATOR to be used where ambient temperatures range from −20 to +150 F.

For complete information and specifications on the new ACTIONATOR, call the nearest Honeywell office, or write (send coupon) to:

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Phila. 44, Pa.

Industrial Division
MINNEAPOLIS-HONEYWELL REGULATOR CO.
Wayne and Windrim Avenues, Philadelphia 44, Pa.

☐ Please send me additional information on the ACTIONATOR.

☐ I'd like a Honeywell sales engineer to discuss applications of the ACTIONATOR in my plant.

Name_____

Title_____

Company_____

Address_____

MINNEAPOLIS **Honeywell**

First in Controls

*Tradename Minneapolis-Honeywell Regulator Co.

retract from its contact with the gears. A molded synthetic rubber diaphragm is installed under the two gears. It permits a reasonable degree of backlash in the mounting of gears within the housing. In operation, the diaphragm is automatically inflated by pressure fluid, thereby taking up all clearance between the upper and lower faces of the gears.

With gears 1.5 in. dia and fluid held at 180 F, the pump delivered a flow of 12 gpm at 60 psi with pump speed of 2200 rpm. When the temperature level was raised to 250 F, flow increased about 0.3 gpm under the same operating conditions. At 2200 rpm, with 60 psi line pressure, the pump required 1.2 hp, with the fluid at 250 F. When pump pressure was dropped to 50 psi, draw decreased to 1 hp. New Products Corp., 3636 Oakton St., Skokie, Ill.

For more information—
Circle 62, inside back cover

Color-Coded Gasket Stock

A plastic gasket and shim stock is color-coded to indicate the twelve different thicknesses that it comes in. The material is also available in the form of die-cut shims for certain types of roller bearings. General Gasket Co., Industrial Road, Clifton, N. J.

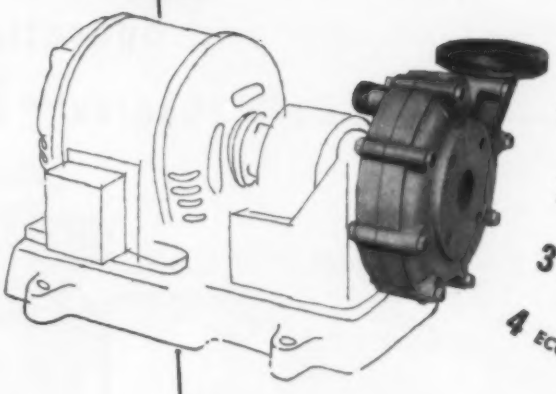
For more information—
Circle 63, inside back cover

Subminiature Three-Pole Relay

A subminiature three-pole relay series has a voltage range up to 48 v d-c, nominal, with pull-in at 75 per cent of nominal value. Coil resistance of up to 6,700 ohm is provided, with

(Continued on page 264)

only 1 material has all 4



...for ACID PUMPS for instance

One of the strongest plastics known . . . .Ace Hard Rubber . . . got the nod for the impeller and casings of this acid pump. Why? (1) It's resistant to almost all corrosives; (2) High strength and abrasion resistance; (3) Won't warp or swell; and (4) Costs much less than corrosion-resistant alloys. Typical result: On one job this hard rubber pump handles 12% hydrofluoric acid, turns on and off twice a minute, 24 hours a day, six days a week . . . a mighty tough test for corrosion-resistant materials?

Many other Ace hard rubber compounds are available . . . tensiles as high as 10,000 psi, moisture absorption as low as 0.04%, power factor as low as 0.006, heat resistance to 300 Deg. F. . . . also many new plastics and rubber-resin blends. All Ace compounds are tailor-made to fit the job . . . never *over*-designed. That's why Ace is the *only* material that meets all four big requirements for parts like acid pumps.

and here's a 5th

Hard rubber sleeve provides electrical insulation as well as mechanical and chemical strength in this coupling for electroplating agitator.

80-pg. Ace handbook free to design engineers.

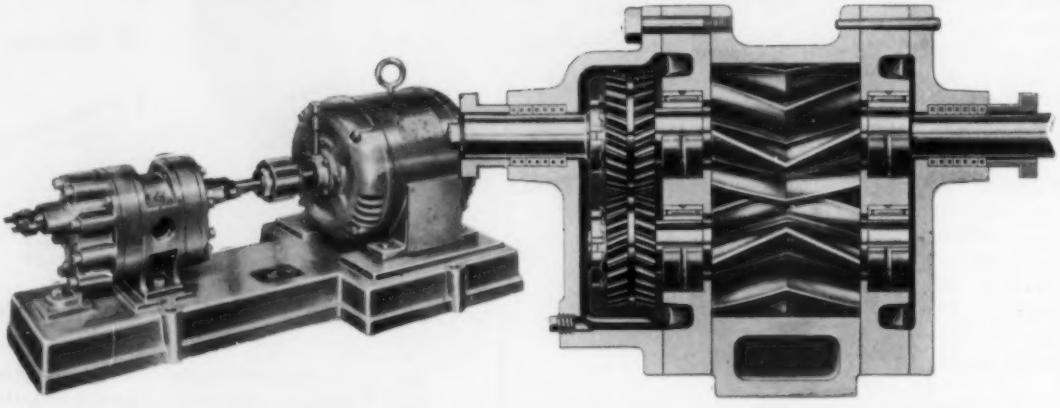
ACE® rubber and plastic products

AMERICAN HARD RUBBER COMPANY
93 WORTH STREET • NEW YORK 13, N. Y.

ORANGE *Cage Type* NEEDLE BEARINGS

meet strict design and operating requirements

in *Sier-Bath* "Gearex"® Pumps



Sier-Bath "Gearex" Pumps (Internal Bearing Type) handle oils and lubricating materials from thin to heavy viscosities, in volumes up to 550 gpm. and pressures to 250 psi. "Gearex" Pumps are distinguished for compactness and high capacity—cool, quiet, vibration-less operation—dependability under severest 24-hour-a-day running.

Cutaway shows 4 Orange Cage Type Needle Bearings mounted on shafts of timing gears and double helical rotors. All parts and clearances are built to close tolerance and must be maintained through years of operation. The Orange cage-type bearings eliminate possibility of roller skewing—run smoothly, quietly—carry the loads in very small space—have been used successfully for eight years in this installation.

Non-skewing rollers – high capacity – small space provide answer to many bearing design problems

Don't lose the opportunity to compact your designs with the high load-to-space ratio of needle bearings because of specific or unusual operating conditions.

The unique advantages of Orange Cage Type Needle Bearings have broadened the use of needle bearings—opened many applications hitherto unsuited to conventional types.

With the Orange cage design, rollers are permanently aligned. The rollers can not skew. True running is assured at relatively high speeds and in any position—horizontal, vertical, tilted or overhung mountings. They are less affected by misaligned mounting or uneven loading. Operation is extremely quiet, even and trouble-free.

Standard sizes from ½" to 8" shaft diameters, with stocks and engineering service in all leading industrial centers. Write for 40-page Engineering Manual M-56 showing details and dimensions.

ORANGE ROLLER BEARINGS

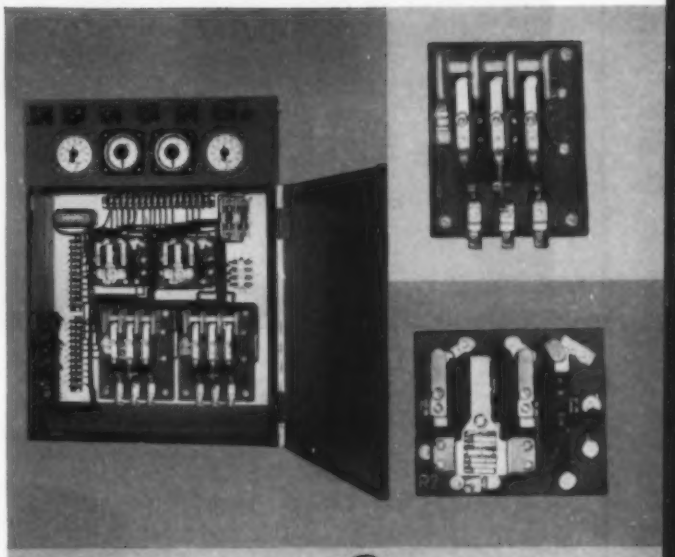
ORANGE ROLLER BEARING CO., Inc.
551 Main Street, Orange, N. J.

Needle Bearings — Staggered Roller Bearings
Journal Roller Bearings — Thrust Roller Bearings
Cam Followers

50 precision shell molds per hour with ASCO CONTROLS

Dependable precision control by ASCO has been a long time feature of a wide range of automatic equipment and machine tools. A typical example is the Shell-O-Matic high speed shell molding machine shown here. The machine produces precision shell molds for casting in ferrous and non-ferrous metals. ASCO solenoid valves sequenced by ASCO relays completely control the operation.

Integrated in the control system are the ASCO control panel, single and dual solenoid valves with watertight molded coils, relays and contactors. These controls help Shell-O-Matic achieve a production rate of 50 precision units per hour.



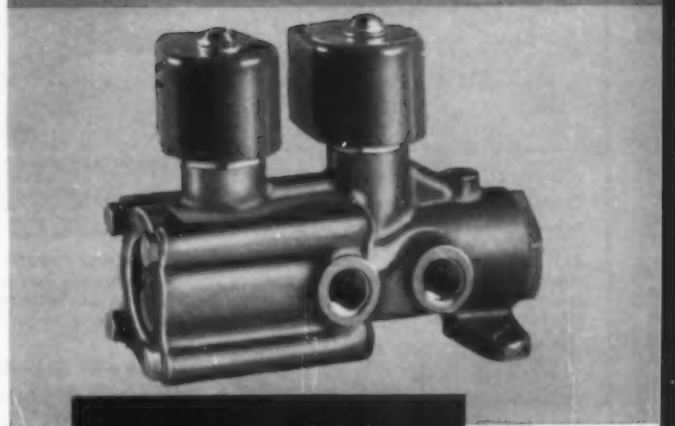
ASCO CONTROL PANEL

This control panel consists basically of two ASCO 1054 Relays and 1035 Contactors. The 1054 is especially designed for rugged industrial use with powerful efficient magnet for positive action. It is a 25 ampere relay, available in a variety of pole combinations up to 12 poles. The Bulletin 1035 is a continuous duty contactor, suitable for all classes of load, with interrupting capacity of 6 times rated current. Standard ratings are to 300 amperes; contactors with higher capacities are available.

ASCO SOLENOID VALVES

ASCO Bulletin 8344 4-way solenoid valves are especially designed for double acting pneumatic or hydraulic cylinders. In this installation watertight luxolene molded coils have been specified since the shell molders are washed down frequently. These poppet type valves provide tight seating with absolutely no leakage. They are power driven in both directions by line pressure. A full line is available: sizes ⅜"– 1" with single or dual solenoids and J.I.C. construction.

These quality products are representative of the complete line of ASCO controls now available. Design *your* control system with ASCO electromagnetic control and solenoid valves. Technical literature and engineering assistance are available. Write ASCO today about your control problem.



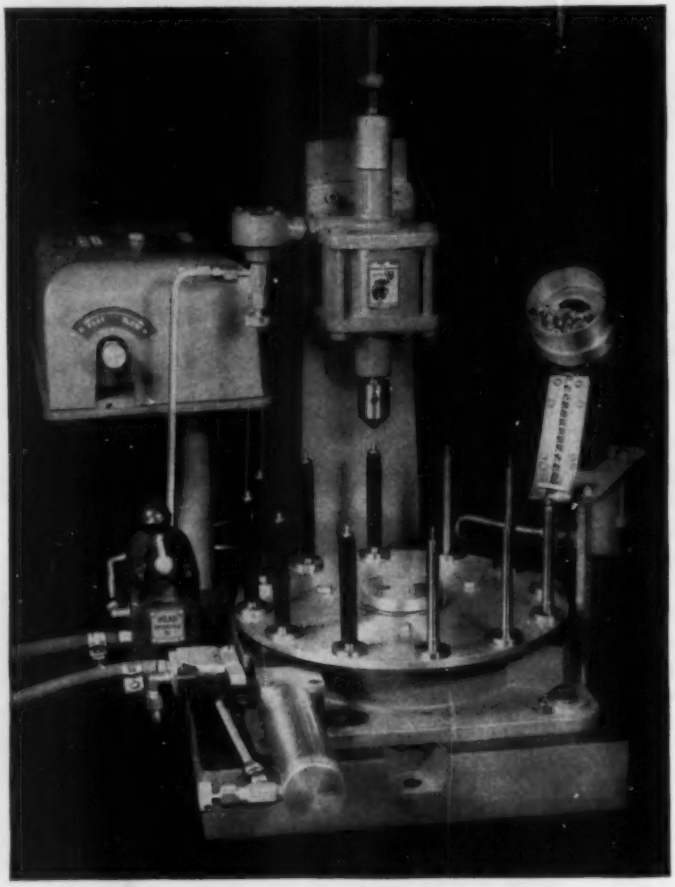
Important announcement . . . *new ASCO plant now being built in Florham Park, N. J., will double production capacity and greatly extend the range of our research, product development and services.*

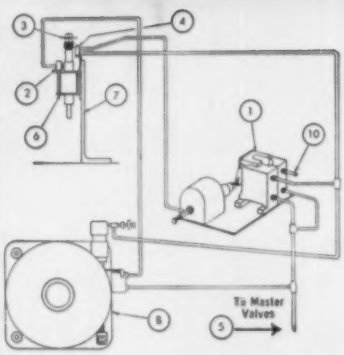
Automatic Switch Co.

385 Lakeside Avenue, Orange, New Jersey

ASCO®

Automation with Air Power

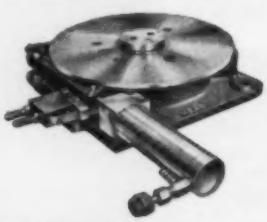




Circuit Diagram of Units in This Photo

Combine readily to feed work to drill press, air impact hammer for a wide variety of operations.

MEAD Rotary Work Feeder is the heart of this machine to crimp eyelets and rings on pen barrels. A simple combination of standard Mead units makes a semi-automatic machine—operator merely loads.



The **ROTARY WORK FEEDER** indexes to 8, 12 or 24 stations, at speeds from 15 to 150 stations per minute. Auxiliary valve actuates drill press feed or other pneumatic tool as each station indexes.

(1) Meadmatic Timer controls cycles per minute and "dwell". (2) Speed control valve and quick exhaust valve regulate advance and retraction of tool. (3) Adjustable depth stop. (6) Single-acting air cylinder. (7) Vertical stand. (8) Rotary Work Feeder. All units mounted on Universal Base.

MEAD

Write for free booklet of 44 "Examples in Air Power Automation".

SPECIALTIES CO., 4114 N. Knox, Dept. PE-17, Chicago 41, Ill.

PATHFINDER IN AIR POWER AUTOMATION

a 1-w power requirement. Temperature range: −45 C to 55 C. Dimensions are $1\frac{1}{8}$ x $\frac{17}{32}$ x $\frac{15}{16}$ in., weight $\frac{7}{8}$ oz. Potter & Brumfield, Inc., Princeton, Ind.

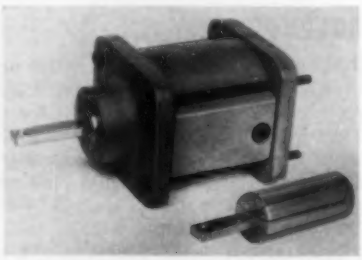
For more information—
Circle 64, inside back cover

Circuit Breaker with Vibration Resistance

This miniature magnetic circuit breaker is for use in protecting electronic equipment. It will withstand 10 G at 55 to 1000 cps. The trip level is said to have been raised to 135 per cent of rated load current.

Units are available for interrupting 50 v d-c at currents from 0.05 to 10 amp and for interrupting 120 rms v, 60 or 400 cps, at current from 1 to 10 amp. Airpax Products Co., Baltimore 20, Md.

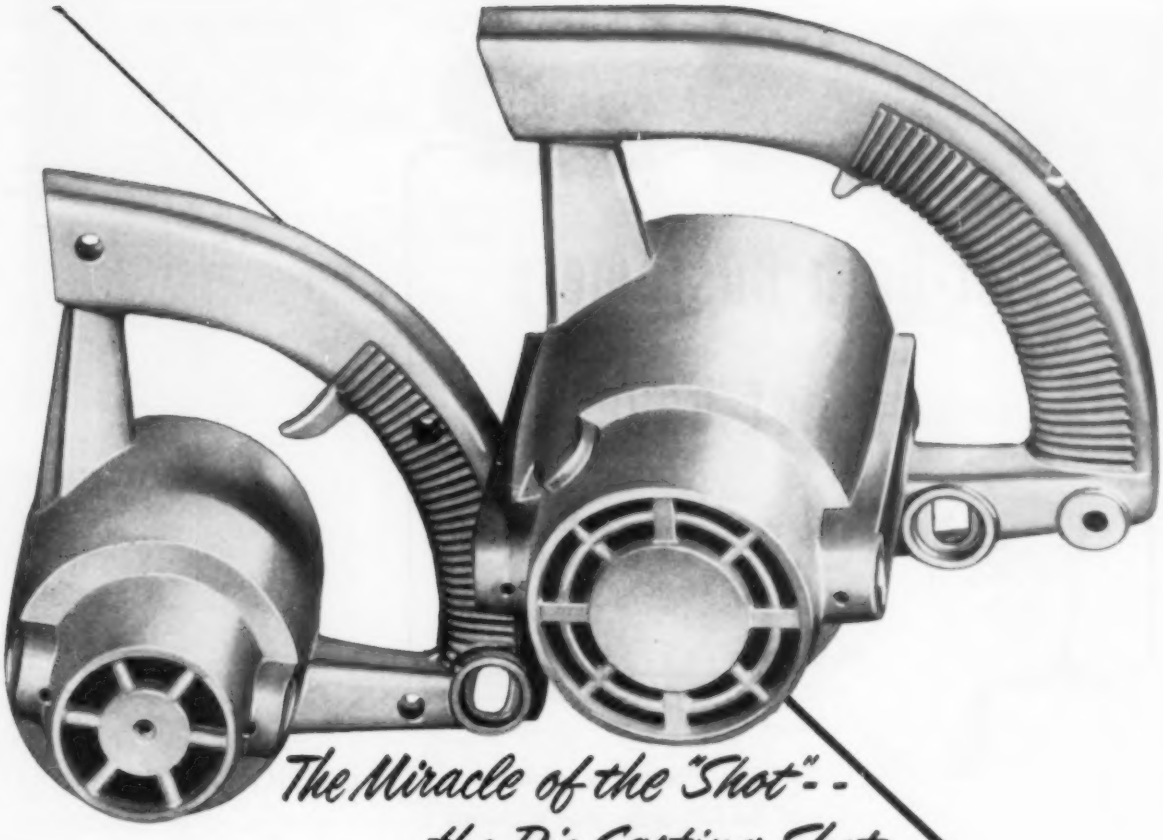
For more information—
Circle 65, inside back cover



A-c Solenoid Has Solid, Slotted Plunger

Delivering 20 lb thrust at 100 per cent voltage this solenoid is available for intermittent duty, in both push and pull types. A solid, cylindrical, slotted plunger is said to eliminate rivet failure. For operation on 115 or 220v, 60 cps, single-phase, a-c. Weight is 6 lb, 11 oz, including plunger.

(Continued on page 266)



The Miracle of the "Shot"--
the Die Casting Shot

with MADISON-KIPP

zinc and aluminum die castings

The "Shooting" of a die casting is spectacular far beyond what can be imagined, even by examining complicated die castings.

The split second interval from molten metal to a casting having *maximum process utilization* must, however, be backed by seasoned skill.

At MADISON-KIPP the practiced, practical die designers have given substantial assistance to highly placed designers and engineers for over a quarter century.

Please clip this ad as a reminder to contact us when you have die casting requirements.

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MADISON-KIPP CORPORATION
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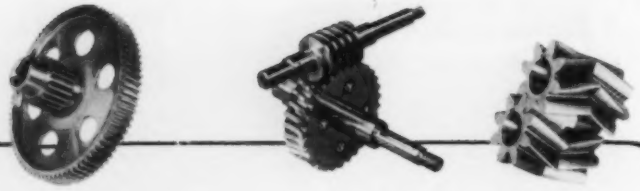
Skilled in Die Casting Mechanics • Experienced in Lubrication Engineering • Originators of Really High Speed Air Tools



Sier-Bath Customers do not have Gear Troubles!

Are you plagued by some, or all, of the following gear problems which Sier-Bath has eliminated for its customers?

- **How to obtain better gears that run quietly and without vibration.**
- **How to avoid early gear wear and failure.**
- **How to get those better gears without increasing the cost.**
- **How to reduce costs of existing gears.**
- **How to be sure your gear drawings have correct details of tooth proportion, tolerances, contact ratio, heat treating and material, to conduct the gears through their mesh in the smooth and lasting manner of a ball rotating against a hard, highly polished and contoured surface.**

Join all the other Sier-Bath customers who let us handle their gear requirements from original design to ultimate superiority for their machines. Send your gear drawings—or request our engineer to discuss your gear problems.

Sier-Bath PRECISION GEARS

All kinds of gears—all materials. Made—cut—shaved—ground teeth. 48" maximum diameter

***Sier-Bath* GEAR & PUMP CO., Inc.**

9238 HUDSON BOULEVARD NORTH BERGEN, N. J.

Founded 1905 Members A.G.M.A.

Also manufacturers of Rotary Pumps and Flexible Gear Couplings

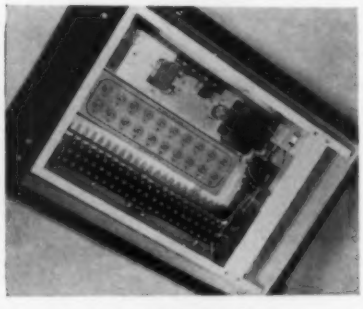
Stroke is 1¾ in. Over-all dimensions of solenoid less plunger: 5¼ x 3¾ x 3⅜ in. Black & Webster, Inc., Newton, Mass.

For more information—
Circle 66, inside back cover

Quick-Connect Coupling

A few turns of the threaded female union coupling actuates two spring-loaded pins, opening or closing the connection. The unit is rated at 5,000 psi and is made to government standards. Wisconsin Hydraulics, Inc., 3165 N. 30 St., Milwaukee 16, Wis.

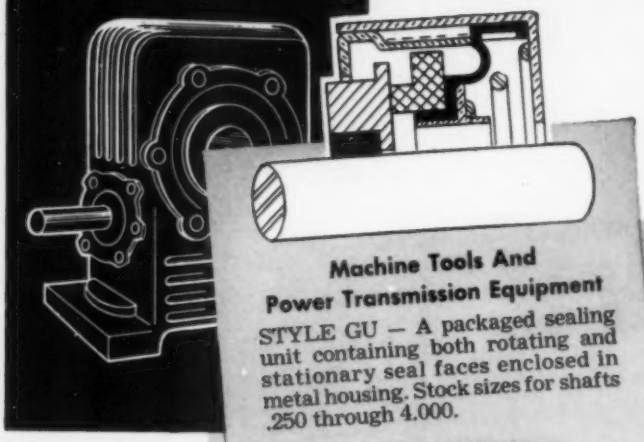
For more information—
Circle 67, inside back cover



Operations Control

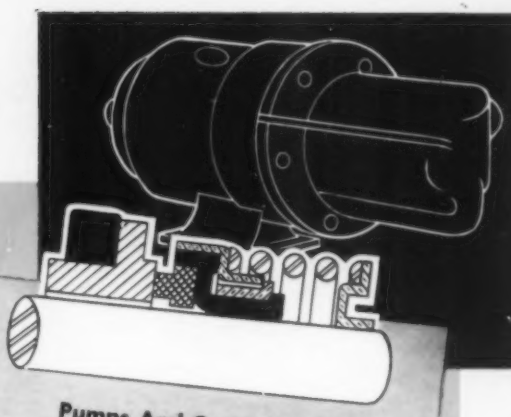
This is a time control device in which a number of multiple contacts are selected for opening and closing independently and individually for any single unit of a group of multiple intervals (or operations). These intervals are independently and individually

(Continued on page 270)



Machine Tools And Power Transmission Equipment

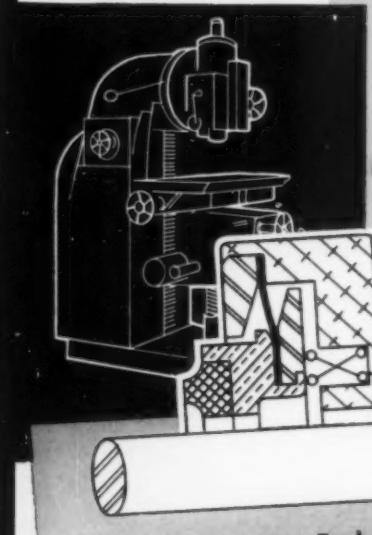
STYLE GU — A packaged sealing unit containing both rotating and stationary seal faces enclosed in metal housing. Stock sizes for shafts .250 through 4.000.



Pumps And Compressors

ROTO-FLEX — Rugged flexibility. Only 3 parts. Single or double units. Stock sizes for shafts .250 through 4.000.

STYLE RFO — A specially designed Roto-flex seal, for installation outside the stuffing box. Stock sizes for shafts .250 through 4.000.



Heavy Machine Tools

STYLE DPC — A high-speed, carbon-faced seal, for more compact installation in heavy industrial machinery. Stock sizes for shafts .250 through 4.000.

A Complete Line

GITS SHAFT SEALS

For Every Application

These modern, mechanical, face-type seals are carried in stock — to save you time and money. Write for detailed data.

GITS BROS. MFG. CO.

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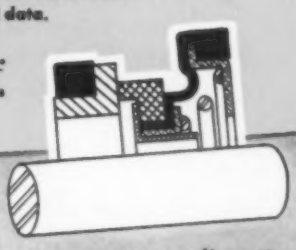
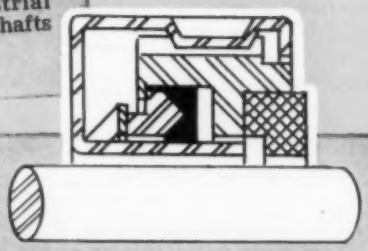
Specialists In Lubricating Devices And Shaft Seals For Almost Half-A-Century



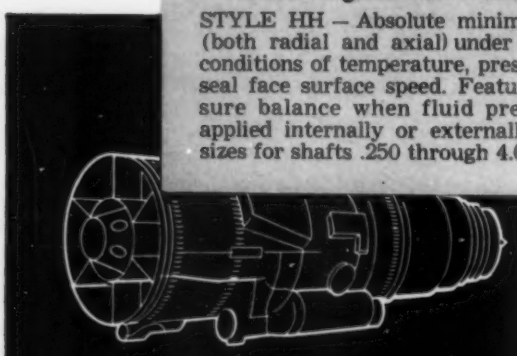
Household Appliances

STYLE SGU—A factory-assembled unit-type seal for the small-budget user. Stock sizes for shafts .250 through 1.000.



Aircraft Engines And Accessories

STYLE HH — Absolute minimal space (both radial and axial) under extreme conditions of temperature, pressure and seal face surface speed. Features pressure balance when fluid pressure is applied internally or externally. Stock sizes for shafts .250 through 4.000.



STAMINA such as you've never seen before!

NEW

HIGH TORQUE HEAVY DUTY 'Jeep' 6

This new Keypoint Engineered engine sets a new standard of quality design in the industrial engine field. Extra durability for parts that wear out first in ordinary engines results in full-time 'Jeep' dependability and long life. To prove this engine's ruggedness in action, Willys engineers ran it at 4,000 rpm under full load in repeated 100-hour tests. Each test simulated 50,000 miles of ordinary vehicle travel. Breakdowns: None. Parts failures: None. Disassembly and careful inspection after all tests revealed that every component was still in exceptionally good condition! For real stamina . . . for high torque at low operating speeds, specify this Heavy Duty 'Jeep' 6.

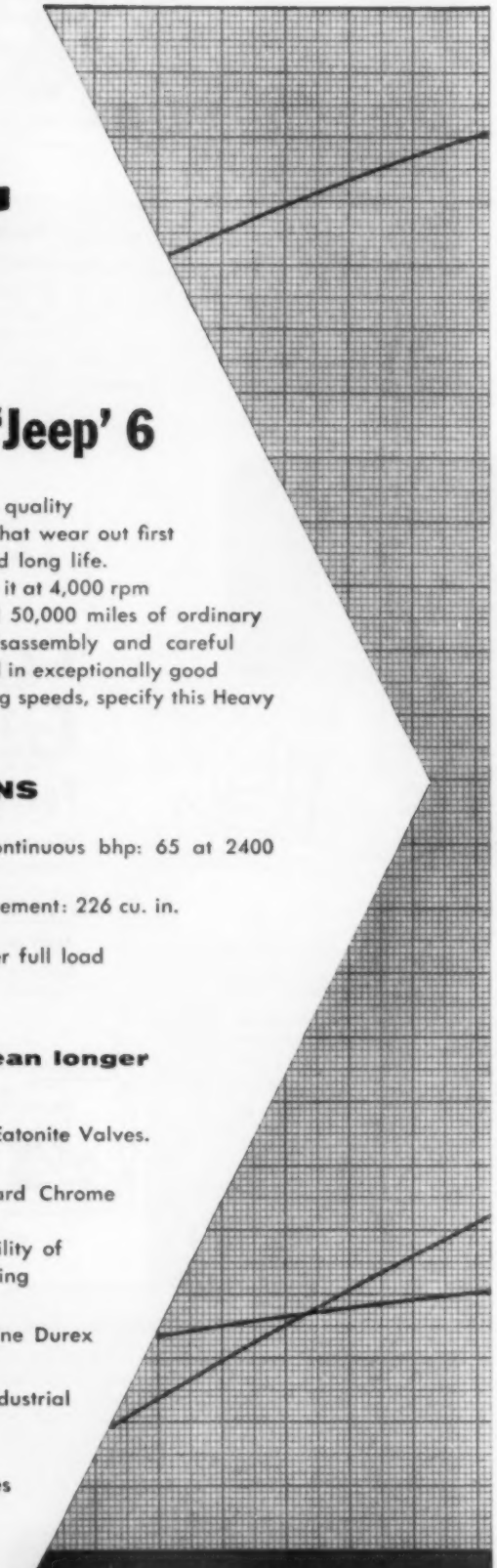
HEAVY DUTY 'Jeep' 6 SPECIFICATIONS

- Maximum Torque: 180 ft. lbs.*
- Maximum Continuous Torque: 142 ft. lbs.* (torque peaks at 1200 rpm)
- Maximum bhp: 92 at 3200 rpm*
- Maximum Continuous bhp: 65 at 2400 rpm*
- Piston Displacement: 226 cu. in.

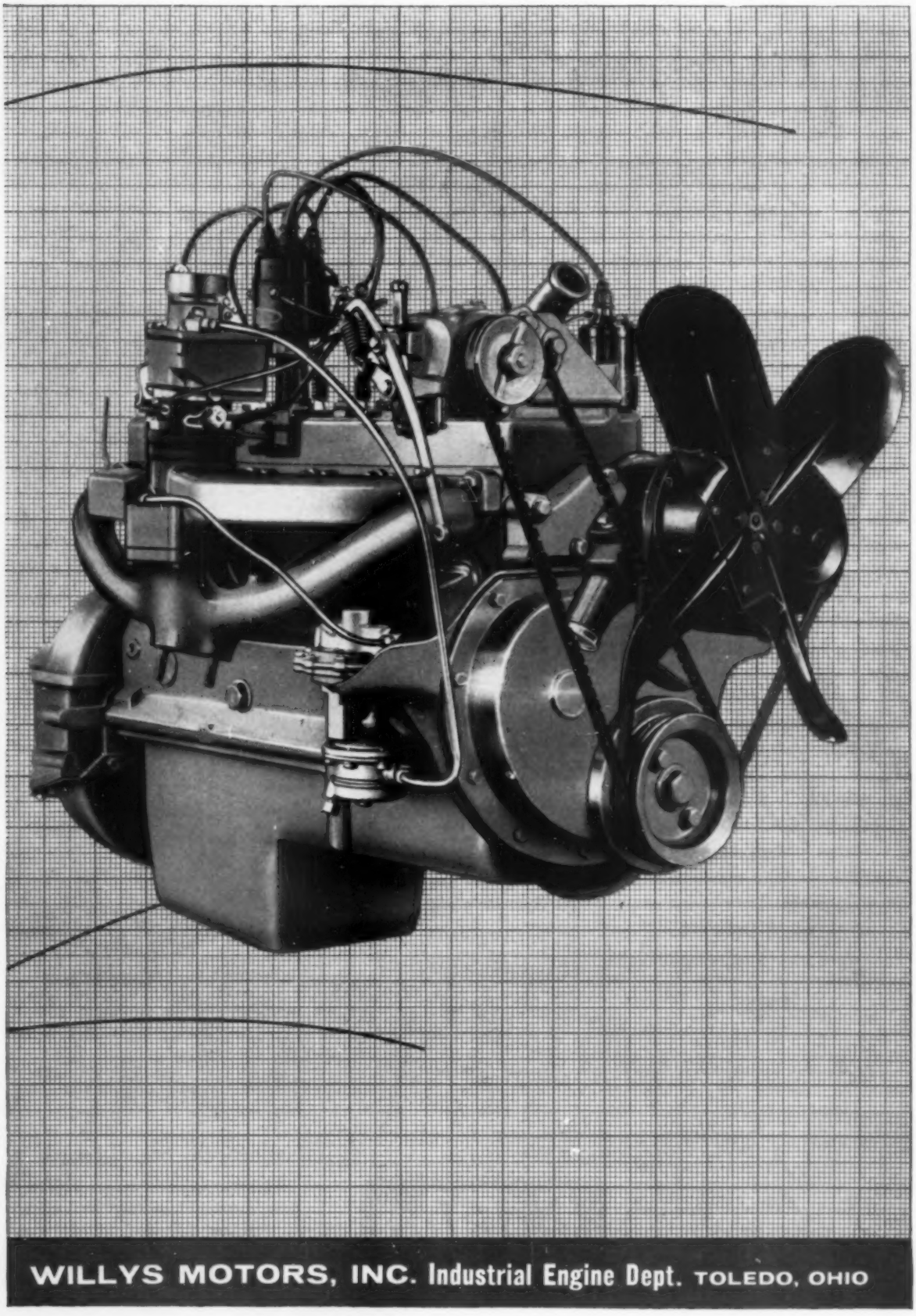
*All tests under full load

These KEYPOINT-ENGINEERED features mean longer engine life, low-cost upkeep

- **POSITIVE VALVE ROTATORS.** Hard Face Stellite or Eatonite Valves. Stellite or Eatonite Valve Inserts.
- **FOUR RING ALUMINUM ALLOY PISTONS** with Hard Chrome Compression Ring and Hard Chrome Steel Rail Oil Ring. New Piston Control Band reduces the possibility of slap and skirt collapse and contributes to outstanding oil economy.
- **NEW PREMIUM HEAVY DUTY BEARINGS** of Moraine Durex
- **FORGED CRANKSHAFT.** 100% counterweighted.
- **HIGH TORQUE CAMSHAFT** specially designed for industrial use provides extra lugging power at low operating speeds.
- **SINGLE CARBURETION AND MANIFOLDING** provides maximum efficiency from every drop of fuel.



Write for full details


WILLYS MOTORS, INC. Industrial Engine Dept. TOLEDO, OHIO

Now available, the latest, revised edition of the B. Jahn Catalog. Scores of case histories show B. Jahn progressive die engineering and ingenuity solving mass production problems for America's most progressive manufacturers.

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adjustable, automatically following a selected sequence or cycle which can be selected to repeat or be reset at the end of a sequence or cycle. Switches being operated by individual cams can be set to operate simultaneously with one another, with an accuracy said to be better than 1/100 sec. The standard selector operates on 115 v, 60 cps, a-c. The twenty snap-action switches provided for energizing responsive devices have contacts rated at 15 amp 120-250 va-c. The shortest time interval obtainable is $\frac{1}{10}$ sec. Each unit is supplied with a maximum of 20 time intervals. The unit may be purchased housed in a JIC cabinet, or without the cabinet for rack mounting. Henry G. Dietz Co., 12-16 Astoria Blvd., Long Island City 2, N. Y.

For more information—
Circle 68, inside back cover

Control Circuitry for Meter-Relays

A miniature plug-in control pack, containing all the basic control circuitry needed for use with contact meter-relays, measures approximately 4 x 2 x 4 in. The standard minimum parts include an isolation transformer, a d-c power supply (including rectifiers), and slave relays to provide 5-amp a-c, 115-v contacts. Tipp-Tronic, Inc., Tipp City, Ohio

For more information—
Circle 69, inside back cover

Hermetically Sealed Switch

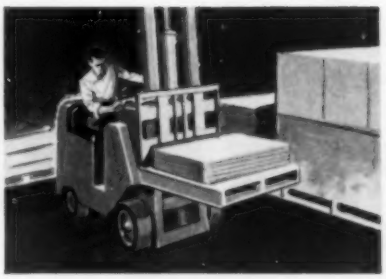
Threaded actuator plunger guide sleeve permits mounting the switch actuator button flush or extended any distance from the mounting board up to $\frac{7}{8}$ in. The switch is hermetically

(Continued on page 274)

CLUTCHES

Spicer

for a wide range of



AUTOMOTIVE . . . INDUSTRIAL AND AGRICULTURAL APPLICATIONS

Ask Dana clutch engineers to help meet your particular power transmission requirements. Dana has the clutch experience and the ability to do the job . . . the result of over 50 years of development in power transmission.

Dana engineers have designed Spicer Clutches to meet practically every specification for automobiles and trucks; for heavy-duty off-highway and industrial applications; for crawler tractors, farm tractors, and many types of self-propelled vehicles; for railroads; and for stationary industrial applications.

Spicer Clutches range in capacity from 6½" diameter single-plate through 15½" two-plate types. These clutches have the advantages of lightness, great strength, and long life. They are produced in Dana plants devoted exclusively to the development and manufacture of clutches.

Ask Dana engineers to analyze your clutch requirements, and request free book describing all of Dana facilities.

DANA will be at the **ROAD SHOW**

DANA CORPORATION
TOLEDO 1, OHIO

SPICER PRODUCTS: Transmissions • Universal Joints • Propeller Shafts • Axles • Torque Converters • Gear Boxes • Power Take-Offs • Power Take-Off Joints • Rail Car Drives • Railway Generator Drives • Stampings • Spicer and Auburn Clutches • Parish Frames • Spicer Frames

Spicer

Experience in Engineering *Ability in Manufacturing*

For heavy-duty special equipment and truck application...

TDA® NOW OFFERS

today's broadest range of

PLANETARY AXLES

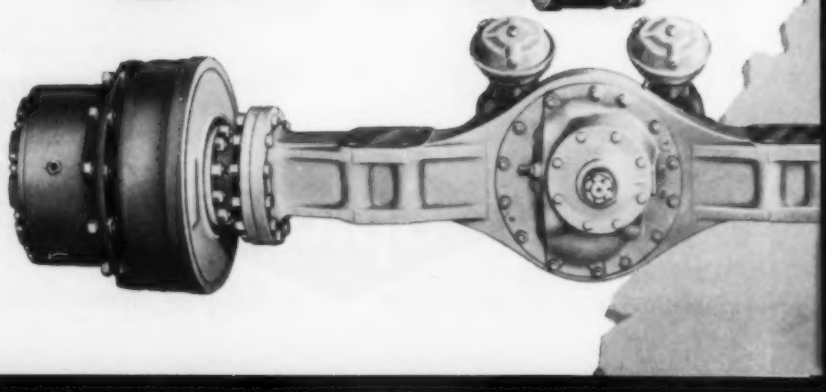
steering and rigid...from 11,000 to 75,000 lb. capacities!

A complete range of new planetary heavy-duty axles—with a steering axle operationally matched to each rigid axle in the line—is now included in the Timken-Detroit® family of advanced design axles. This matching of steering and rigid units brings you just the right axles for every requirement in both special off-the-road equipment and heavy-duty trucks.

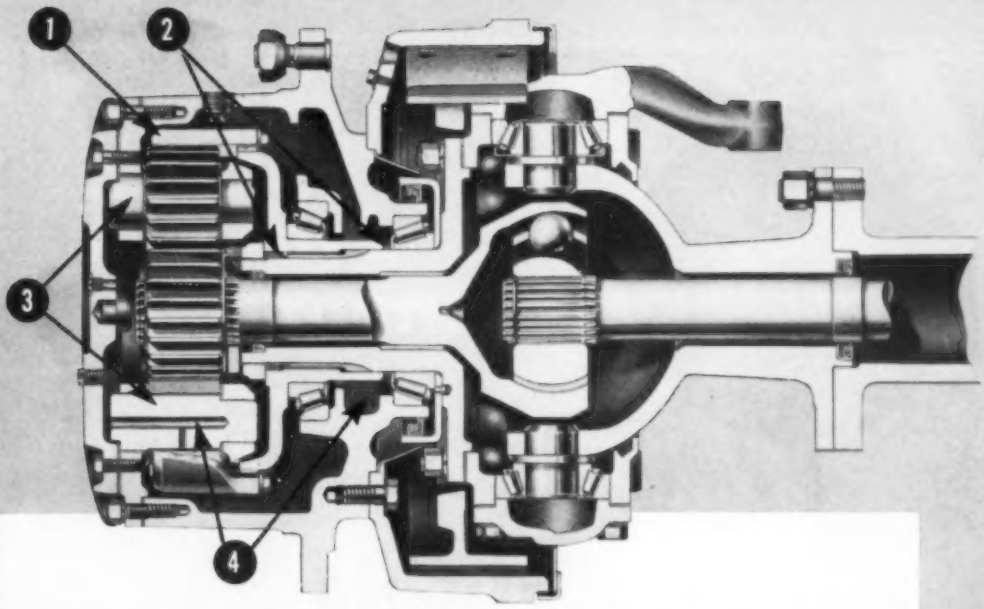
Years of research and development have resulted in these new and exclusive planetary OUTER-END features: *floating ring gears—concentrically mounted ring gear hubs—full-flow lubrication of all bearings and planet gears—special forged bronze planet pinion pins—and an unusually high degree of parts interchangeability.*

Because of their versatility, ruggedness and almost unlimited gear reductions, these new, full planetary axles are going into use all over the world on heavy-duty prime movers, big four-wheel tractors, off-road rock wagons, mining equipment, heavy-duty scrapers, front-end loaders and other heavy-duty equipment.

PLANETARY STEERING AXLE



PLANETARY RIGID AXLE



Only New Timken® Full Planetary Design Brings You These Features for Extra-Long Life, and Extra Dependability:

1. **New Floating Ring Gear** . . . Ring gear and hub are two separate pieces. Ring gear is free to float radially. This feature, combined with floating sun gear, assures equal distribution of stresses to *all* planetary gears, gives longer, trouble-free gear life.

2. **Concentrically Ground Ring Gear Hub and Spindle Mounting Surfaces** . . . Concentrical grinding around a common center assures perfect alignment and fit—plus freedom from bending forces on the hub and spindle splines. Splines absorb only torsional stresses from the ring gear and transmit them to the housing.

3. **Special Forged Bronze Planet Pinion Pins** . . . Pins are forged of special alloy bronze for longer, trouble-free operation. Rifle drilled lubrication channels and machined lubrication flats assure full time lubrication of the planet pinions. When cover is assembled pin is locked in place to prevent rotation—resulting in longer pin life.

4. **Full-Flow Lubrication** . . . Design of Timken planetary axles assures constant flow of lubricants to wheel bearings and all planet gears while vehicle is in operation. Wheel hub and planetary spider pick up oil in the cast reservoirs as they rotate and channel it to wheel bearings and pinions. When vehicle is not in motion oil is retained in these chambers providing ample initial lubrication for all moving parts.

5. **High Degree of Parts Interchangeability** . . . Important to service and operation is the high degree of parts interchangeability between both rigid and steering axles in the same planetary series. This means a smaller parts inventory, low maintenance costs and more productive time with Timken planetary axle equipped vehicles.

Plants at:
Detroit, Michigan • Oshkosh, Wisconsin
Utica, New York • Ashtabula, Kenton and Newark, Ohio • New Castle, Pennsylvania

©1957, RS&A Company

For complete information on the TDA family of planetary axles—write Timken-Detroit Axle Division, Detroit 32, Michigan . . . or visit the TDA display at Booth No. 364 at the 1957 Road Show—Chicago Amphitheater, January 28th through February 2nd!

TIMKEN Detroit AXLES
TIMKEN-DETROIT AXLE DIVISION
ROCKWELL SPRING AND AXLE COMPANY
DETROIT 32, MICHIGAN
The Accepted T D A Standard

WORLD'S LARGEST MANUFACTURER OF AXLES FOR TRUCKS, BUSSES AND TRAILERS

TIME to check FASTENER COSTS and reduce them

with

STUD WELDING

. . . the fastest electric arc welding process for end welding fasteners

KSM®

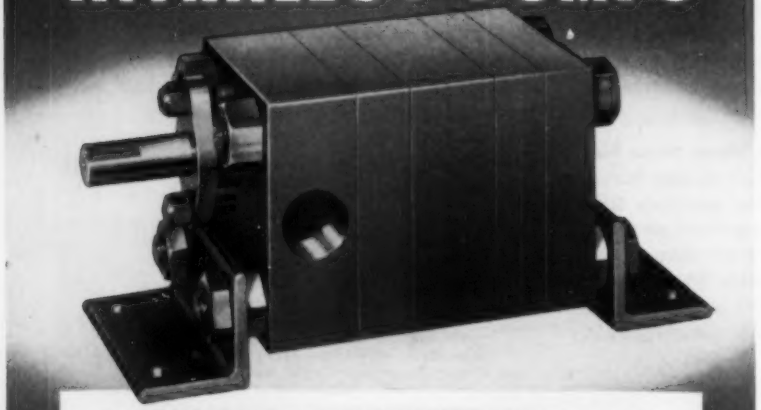
KSM PRODUCTS, INC.
stud welding division
MERCHANTVILLE 48, N. J.

sealed, filled with dry, inert gas and is said to be moisture and dustproof.

Switch has $\frac{1}{8}$ in. overtravel with $\frac{1}{8}$ in. pretravel along the plunger. Haydon Switch Inc., Waterbury, Conn.

For more information—
Circle 70, inside back cover

NORTHERN NITRALLOY PUMPS



Unique block construction permits selection from a wide choice of metals for virtually any pumping need. Proven in thousands of installations . . . backed by 50 years of engineering and production experience. Unexcelled for precision manufacture, accurate assembly and dependable, long-life operation. Pressures to 2,000 P.S.I. Capacities from ¼ to 146 GPM. *Write for free catalog and engineering data.*

NORTHERN ORDNANCE, INCORPORATED
Subsidiary
NORTHERN PUMP COMPANY
MINNEAPOLIS 21, MINN.

Repeat Cycle Timer

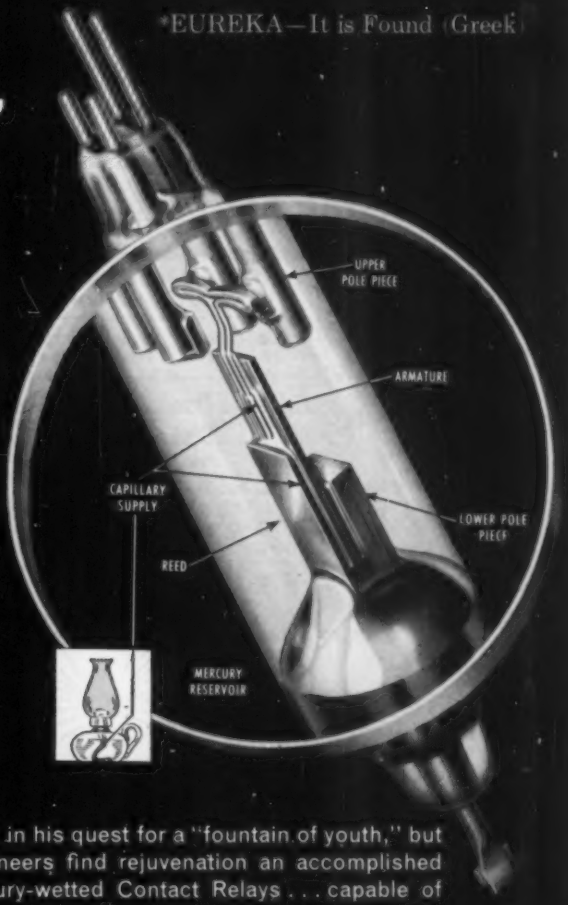
For temperature control of equipment such as heaters, percentage of uniform temperature is set by turning the knob and pointer to the calibrated position on the dial. No other adjustment is necessary. Automatic timing of holdfire controls, mixing machines, testing equipment, fans, heaters and other similar equipment is also possible. The total time cycle can be adjusted from 15 sec to 24 hr, with a range of adjustability to 94 per cent for "on" and "off" periods. Timer is equipped

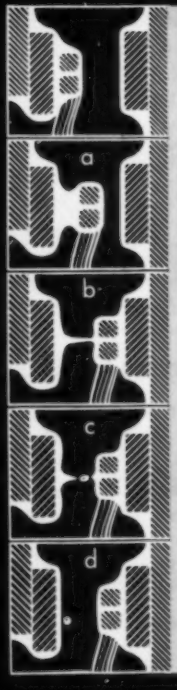
(Continued on page 276)

XEMPIKA*

*EUREKA—It is Found (Greek)

INDUSTRY FINDS A "FOUNTAIN OF YOUTH" IN THIS SELF-REJUVENATING CLARE RELAY





Drawings (left) from stroboscopic photographs show the cycle. (a) Filament of mercury forms between the contacts as they separate. (b) This becomes narrower in cross section and (c) finally parts at two points, allowing a globule of mercury to fall out. Mercury flows up the capillary path, replaces amount lost, restores the equilibrium. (d) The momentary bridging of the parting contacts—and the extremely fast break that ends it—minimizes the arc and adds greatly to contact load capacity. Contact closure between the two liquid surfaces bridges mechanical bounce and prevents any chatter from appearing in the electrical circuit.

Ponce de Leon failed in his quest for a "fountain of youth," but modern design engineers find rejuvenation an accomplished fact in CLARE Mercury-wetted Contact Relays . . . capable of billions of operations.

Contacts of these relays are constantly renewed. By capillary action, like that of a lamp wick, a new film of mercury coats the contacts with every make and break.

The magnetic switch is sealed in a high-pressure hydrogen atmosphere in a glass capsule. Surrounded by the operating coil, the capsule is enclosed in a vacuum-tube-type steel envelope.

Unlike ordinary relay contacts, these contacts never wear out; never get dirty; never lock or weld; never get out of adjustment; never bounce.

Send for CLARE Engineering Bulletins No. 120 and 122. Address C.P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare & Co., 659 Bayview Avenue, Toronto 17. Cable Address: CLARELAY.

CLARE RELAYS

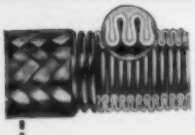
FIRST in the industrial field

FLEXON®
METAL HOSE *Design Briefs*

Now, Greater Dependability, Longer Life for Flex Connections with New Stainless Steel Rex-Weld

Make your Selection Here...

I.D. (In.)	Nominal O.D. (In.)		Minimum Inside Bend Diameter (In.)		Burst Pressure	Weight Per Foot (lbs.)	
	RW 80	RW 81	Repeated Flexing	Static Bend	(psi)	RW 80	RW 81
¼	½	5/8	12	7¾	16,500	.20	.36
3/8	11/16	13/16	14	10¼	14,000	.27	.41
½	27/32	31/32	16	11	12,400	.47	.65
¾	1 17/64	1 13/32	21	17	10,500	.90	1.33
1	1 35/64	1 11/16	26	18	8,500	1.04	1.59
1¼	1 57/64	2 1/16	30	21	7,600	1.81	2.39
1½	2 ¼	2 7/16	35	22	6,600	2.19	2.71
2	2 37/64	3 5/64	44	24	4,650	2.97	3.78



RW-80 is unbraided. RW-81 has stainless steel braid. A complete selection of factory-attached fittings is available to meet all requirements. Data on larger sizes (to 6" I.D.) available on request.

FLEXON®
The Complete Line for good connections

REX-WELD
corrugated metal hose is available in stainless steel, steel, bronze and alloys; sizes 3/16" through 24", I.D.; for burst pressures to 18000 psi.

REX-FLEX
corrugated stainless steel hose; sizes 3/16" through 6"; working pressures to 3100 psi.

REX-TUBE
interlocked and square locked type hose and tubing in steel, bronze, stainless steel and other alloys; sizes 3/16" through 12", I.D. for low and moderate pressures and for use as conduit, ducting, exhaust, protective armor, etc.

CATALOG No. 152
gives basic specifications and application data for Flexon Metal Hose. Write for your copy, today.

New stainless steel Rex-Weld corrugated metal hose makes possible opportunities for greater economy in scores of flexible connection applications.

If corrosion is a problem, internally or externally, specify stainless steel Rex-Weld. If your cost of replacing flexible connections is high, you can reduce the frequency of replacement by specifying stainless steel Rex-Weld. Similarly, if the cost of downtime or the cost of interrupting continuous processes makes less frequent replacement of flexible connections imperative, specify stainless steel Rex-Weld.

Basic specifications for stainless steel Rex-Weld are given above. Check your requirements against this data, today, and determine where the corrosion resistance and extra durability of stainless steel Rex-Weld will pay dividends for you. Write for full information.

RW27

FLEXON® QUALITY
proved in service and backed by over 54 years manufacturing experience

Flexonics *Corporation*
CHICAGO METAL HOSE DIVISION
1351 S. THIRD AVENUE, MAYWOOD, ILLINOIS
FORMERLY CHICAGO METAL HOSE CORPORATION
Manufacturers of flexible metal hose and conduit, expansion joints, metallic bellows and assemblies of these components.
In Canada: Flexonics Corporation of Canada, Ltd., Brampton, Ontario

with a visible dial, snap-action switch with silver contacts and a synchronous motor. Rating: 110 v, 60 cps; 110 v, 50 cps, a-c. Dimensions: 5 x 3 x 3 in. Zenith Electric Co., 152 W. Walton St., Chicago 10, Ill.

For more information—
Circle 71, inside back cover

Temperature Regulator

A safety-type temperature regulator will close automatically to prevent overheating and possible damage to products in process, in the event the thermostatic unit is accidentally damaged. A 4⅜ in. bellows is used for more powerful response and smoother modulating action in controlling the flow of steam, hot water or other medium. Because the device has a special tight-closing, single-seated valve, it is suitable for "dead-end" or terminal service. It is available from ¼ to 2 in. Robertshaw-Fulton Controls Co., Box 400, Knoxville, Tenn.

For more information—
Circle 72, inside back cover

Miniature Magnetic Clutches

Clutches of this type are designed for electrical control of rotary mechanical functions, such as the remote setting or adjusting of potentiometers, synchros and other rotating components. They also may be used as controlled loads or stops.

Model 583 is 1¼ x 2 1/16 in. length.

(Continued on page 280)

WHEN GASKETING MUST LAST LIFE OF PRODUCT

SWITCH TO RUBATEX CORD

Shown here is a Brown ElectroniK Potentiometer used for measurement and, where desired, the control of many variables. Rubatex Neoprene Cord's lasting qualities, ability to stand up under wide variations in temperatures, atmosphere and usage make it ideal as gasketing in the door of the instrument case.

Quality controlled, closed cellular Rubatex Cord helps insure lifetime accuracy of Brown ElectroniK Potentiometers.

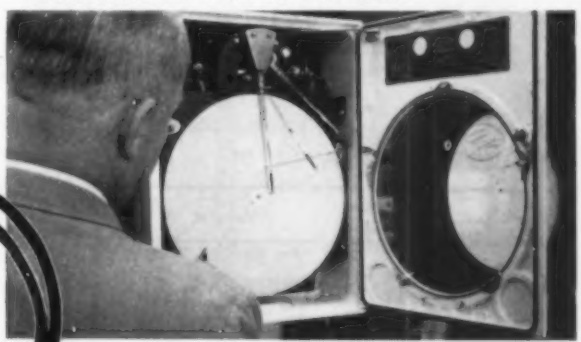
"An instrument door may be opened daily for 30 years; but the gasket should keep a tight seal to insure the accuracy of the instrument. We tested Rubatex Cord for several months before deciding to buy it. You can bet we wouldn't have ordered it if we weren't satisfied of its wearing qualities."

John A. Caldwell
Chief Liaison Engineer
Minneapolis-Honeywell Regulator Company
Brown Instruments Division
Philadelphia, Pa.

By buying Rubatex Closed Cellular Neoprene Cord in precut lengths, Minneapolis-Honeywell Regulator Company, Brown Instruments Division, solved the problem of controlling the dimension of cord for gasketing case doors of their ElectroniK Potentiometers. They are now able to get the quality control they need—plus easier and swifter application since it is precut to lengths required.

Rubatex Cord is also ideal as weather stripping, appliance and automotive gaskets and drum seals. Produced in continuous lengths in $\frac{1}{8}''$ and $\frac{1}{2}''$ diameters. Can be supplied in polymers other than neoprene. Other shapes can also be furnished. For quotation, submit sketch or drawing.

Rubatex Cord is easily applied in strips which are fitted into grooves in the instrument casing to which an adhesive has been applied. The closed cellular structure of Rubatex prevents any crimping at the corners—assurance of full effectiveness of the seal.



Uniform size, ability to return to original dimension after extended pressure are two of the outstanding features of Rubatex Cord which make it applicable as an effective gasket in this Brown Instruments Chart Recorder.

RUBATEX
CLOSED CELLULAR
NEOPRENE CORD

Send for Free Sample and full details

RUBATEX DIVISION, Dept. P-1
GREAT AMERICAN INDUSTRIES, INC.
Bedford, Virginia

For full details and sample of the new Rubatex Closed Cellular Neoprene Cord—print your name in space below, attach to your company letterhead and mail to us.

Name _____

Now – Cleveland provides a single source for all your socket screw requirements

Simplifies specification, cuts paper work, speeds delivery

CLEVELAND STANDARD SOCKET SCREW PRODUCTS
UNIFIED THREADS—CLASS 3A FIT

Type	Standard Sizes (diam.)	Material
Socket head cap screws	#0 to 1½ in. (larger sizes avail.)	Alloy steel, heat treated or Nonmagnetic 18-8 stainless
Set screws (cup, half dog, flat, cone or oval points)	#0 to 1 in. (#0-#3, cup point only)	Alloy steel, heat treated or Nonmagnetic 18-8 stainless (to ½ in., cup point only)
Flat head socket cap screws	#4 to ¼ in.	Alloy steel heat treated
Button head socket cap screws	#4 to ⅜ in.	same
Shoulder screws (stripper bolts)	¼ to ¾ in.	same
Dowel pins	⅛ to 1 in. (nominal size and .001 in. oversize for repair)	same
Pressure plugs	⅛ to 1¼ in. NPTF	same
Socket screw keys	.028 to 1 in. across flats; short or long arm	same

Cleveland has expanded its socket screw line to provide a single source for all your socket head needs.

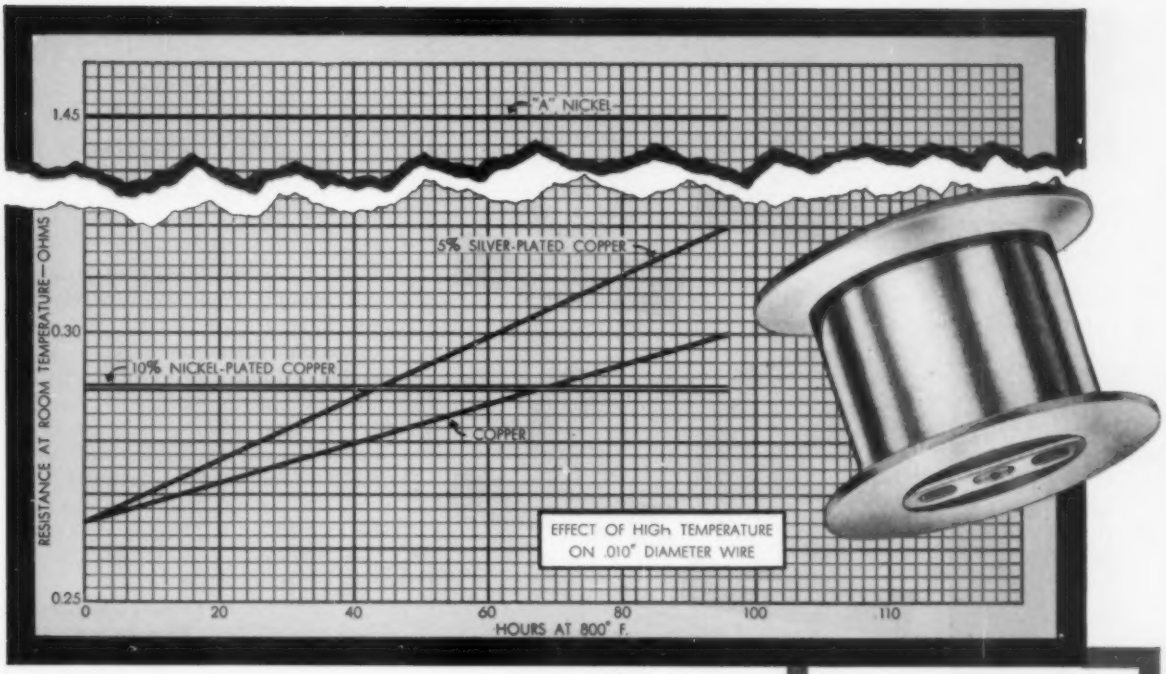
At the same time, and in conjunction with opening its new plant, Cleveland is doubling its factory warehousing capacity. This, plus the latest materials handling equipment, will enable Cleveland distributors to get same-day shipment of your larger orders.

Included in the expanded Cleveland socket screw line are precision dowel pins. While not a socket head product, they are basic fasteners for the important tool and die industry, where they are closely associated with socket head cap screws and shoulder screws. We offer them as part of a complete service.

Cleveland socket head cap screws are upset forged from heat-treated alloy steel. This results in symmetrical, unbroken grain structure in heads, threads and fillets—greater fatigue and tensile strength, stronger fasteners.

Write for latest literature and technical data. Then see your local Cleveland Cap Screw distributor for all your socket screw requirements.

THE CLEVELAND CAP SCREW COMPANY
4444-4 Lee Road, Cleveland 28, Ohio



Nickel-plated copper...

for high conductivity at elevated temperatures

SYLVANIA's Nickel-plated copper wire combines the conductivity of copper with the corrosion-resistant properties of nickel for applications involving temperatures ranging from 350° Fahrenheit to 700° Fahrenheit.

Equal lengths of Nickel-plated copper and three other wires were heated in air at 800° Fahrenheit for an extended period to determine the effect of heat on conductivity.

Nickel-plated copper, more than any of the other wires except for pure nickel, holds its original low resistance. It's this feature which, in many cases, has made Nickel-plated copper more desirable than costlier wires used where conductivity must remain constant under high temperature environment.

Nickel-plated copper wire can be supplied in a full range of diameters from .250" to .005".

Sylvania is the only major wire supplier with complete facilities for plating and cladding wire. This makes it possible to provide you with an experienced, objective recommendation as to whether a plated or a clad wire is best suited for your application.

In addition, Sylvania's Parts Division offers you complete 4-way service including custom molded plastic parts, small metal parts ranging from wire forms to deep drawn parts, and special electronic components. Write for the "Portfolio of 4-way Service" and the new technical bulletin on Nickel-Plated Copper Wire.

SYLVANIA PARTS DIVISION

Sylvania Electric Products Inc., Parts Division, Warren, Pennsylvania

SPECIAL WIRE | METAL STAMPINGS | MOLDED PLASTIC | ELECTRONIC COMPONENTS

4-way service from one source

ELECTRIC

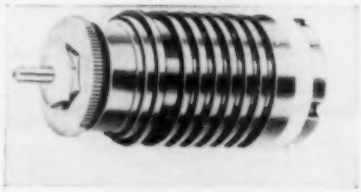
Wheels Engineered for the Job

WRITE US FOR RECOMMEN-DATIONS

Rear Tractor Wheel for Demountable Rim
Planter Press Wheel—one piece rim with or without rubber tire
Rear Tractor Wheel Reversible
Pick-up Wheel Crown-face Steel Rim
Garden Tractor Wheel Reversible
Combine Wheel Reversible
Press and Gage Wheel Rubber Tire
Spreader Wheel
SAE Implement Wheel Reversible

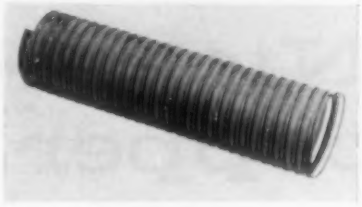
ELECTRIC WHEEL COMPANY

2805 SPRUCE · QUINCY, ILLINOIS



It has a maximum combined braking and clutching torque of 8 in-oz. Model 543 is 1¾ x 4⅛ in. length. It has a maximum combined braking and clutching torque of 35 in-oz. Both clutches are the solenoid-operated, dry-disc type requiring no slip rings. Backlash is said to be eliminated. They are fixed-coil clutches designed for high cycling rates and operation at 24 and 48 v. Positioning does not affect their operation. Helipot Corp., Newport Beach, Calif.

For more information—
Circle 73, inside back cover



Flexible Duct

Vinyl-coated glass fiber fabric with a supporting spiral made from stainless steel provides a duct that bends 90 to 180 deg. Dept. AD, Wiremold Co., Hartford 10, Conn.

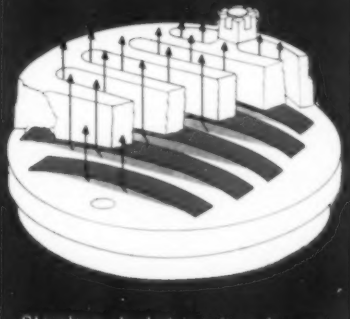
For more information—
Circle 74, inside back cover

Variable Speed Transmissions

This variable speed transmission is adjustable over a range of 8:1, with settings adjusted either manually or automatically while unit is at standstill or in motion. Transmission components run in oil and are completely enclosed. Optional spur, bevel, or worm gear reductions are available and may be installed in any of four positions or planes. Only two sizes of socket wrenches are needed for dismantling and reassembly of complete transmission. Transmission control is arranged by either electrical,

(Continued on page 283)

This compressor valve works with no impact for longer life, best efficiency



Stainless steel strips, in red, open the Feather Valve ports by rolling contact against the lower plate. There is no impact.

The Feather* Valve is the lightest, simplest, quietest compressor valve ever developed. Flexible strips of stainless steel open and close the valve ports with a gentle rolling contact. There is no destructive impact . . . even when the valve is operating as fast as forty times a second.

This lack of impact assures long life and negligible maintenance. The valve itself is all but indestructible. Absence of buffer plates and cushioning devices give it extreme simplicity.

The Feather Valve is quiet and reliable because of its lightness and tight contact seating. Valve action is very sharp. There is virtually no slip or back flow. As a result, you get minimum valve loss and use minimum power.

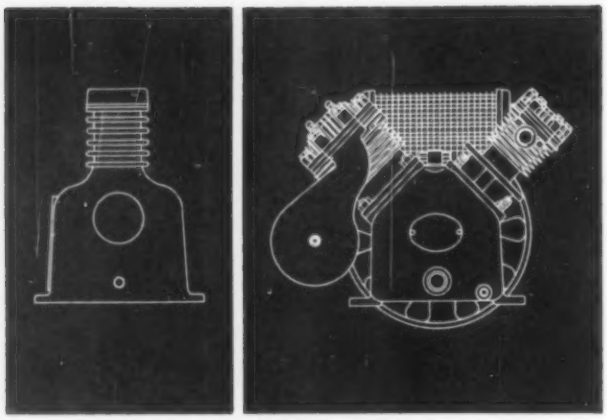
To get the utmost in performance, be sure you specify Worthington when you buy your next compressor. Worthington Corporation, Harrison, N. J. K.6.2

WORTHINGTON

*Reg. U. S. Pat. Off.

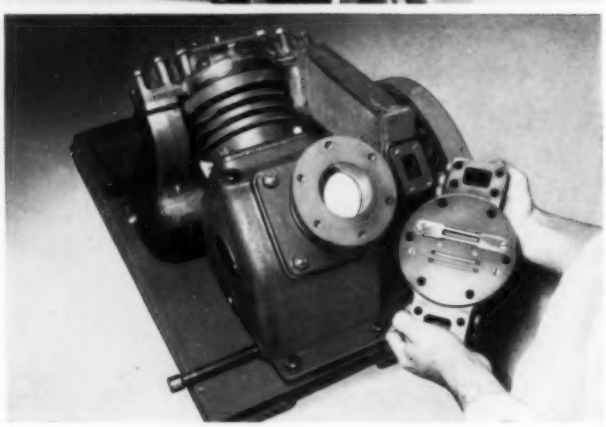
WHAT'S YOUR C.Q.?*

*COMPRESSOR QUOTIENT



In-line or V-type—which is more efficient? In certain fields, this is a hotly debated subject. In compressors, however, most authorities agree that the V-type design provides better balance, smoother running, and better cooling. Besides building only the more efficient V-type design, Worthington casts each cylinder separately from the crankcase. Air thus flows completely around the isolated cylinders, increasing efficiency and saving power dollars.

Why is this connecting rod "aerodynamically" sound? This articulated connecting rod design assures smooth effortless operation, less bearing wear and longer life. It's used in all Worthington radial compressors because it lowers crankpin bearing pressure. One large bearing carries peak connecting rod loads which occur at successive intervals. It's aerodynamically sound because the design is also used in all modern radial aircraft engines.



What important maintenance feature is he demonstrating? When a compressor is operating, valves open and close as many as thirty-three times a second. Valve maintenance is therefore of major concern to all users. Unlike many other makes which require replacement of the complete cylinder or head, all Worthington compressors are equipped with individually replaceable valves and valve guard seats. This is just one of the many Worthington features which save you time and money.

PC. 6.4

To increase your C. Q., write today for the complete story on Worthington's line of standard compressors. Ask for bulletins H-630-B1 and H-605-B3C. Address Section PC64, Worthington Corporation, Harrison, N. J. In Canada: Worthington (Canada) 1955, Ltd., Toronto, Ont.

WORTHINGTON

SPECIFY THESE WORTHINGTON STANDARD PRODUCTS ON YOUR EQUIPMENT

Air Compressors • Pumps • Multi-V-Drives • Allspeed Drives

precision strip for electronics applications

From 0.0005 in. to 0.040 in. thick and 0.090 to 6 in. wide, these alloys are available as special-tolerance strip:

Beryllium Copper
Phosphor Bronze
Nickel Silver
Brass
Chromium Copper
Stainless 17-7PH
Invar
Magnetic: High Nickel

Some immediately available. Others rolled to order in 2 to 21 days. Can be supplied in coils or straight lengths with slit or filed edges—also cadmium plated.

Write for Bulletin 7 TODAY.

PENN
PRECISION PRODUCTS, INC.
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New York *BERYLLIUM COPPER SUPPLY CO.* *Little Falls, New Jersey*
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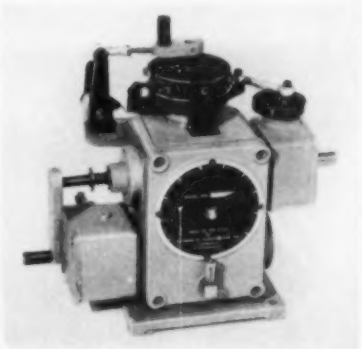

mechanical, hydraulic, or pneumatic means.

Transmission of power is affected through multiple contact of driving and driven discs which are free floating on splined shafts equipped with only moderate axial loading. Discs are replaceable. George E. Clentimack Co., Inc., 229 West St., N. Attleboro, Mass.

For more information—
Circle 75, inside back cover

Solenoid Valve For 100 Psi

The valve may be secured with a full $\frac{3}{8}$ or $\frac{3}{4}$ in. orifice. Continuous duty solenoids are available from 6 v d-c to 440 v a-c. Overall length is $2\frac{17}{32}$ in.; the $\frac{3}{4}$ valve, $3\frac{3}{4}$ in. Coil diameter of either size valve is 2 in. Dept. 311-A, Hays Mfg. Co., W. 12 St., Erie, Pa.

For more information—
Circle 76, inside back cover

Miniature Slip Clutch

The miniature slip clutch is manufactured in 48, 64, 72, 80, 96 and 120

(Continued on page 286)

Designing for High Temp?

Designing for Low Temp?

You Need the Special Advantages of Engineered Lubricants from ANDEROL

The products you design can be used at any temperature without change of lubrication . . . if your designs include a specially engineered Anderol Lubricant. Call the Lehigh Lubrication Specialist while your product is still in the design stage. Regardless of volume or requirements, Lehigh will engineer a special Anderol Lubricant to do the job.

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For complete data and government specifications. Our laboratories are at your service.

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ENGINEERED LUBRICANTS
Lehigh Chemical Company
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WAGNER ELECTRIC MOTORS . . THE CHOICE OF LEADERS IN INDUSTRY

smaller, lighter fractional horsepower motor solves problems for the design engineer

Type RK, Capacitor-start, ⅛, or ¼ hp.

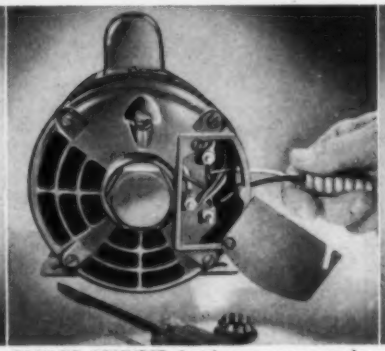
the WAGNER "48"

Here's the 48 frame motor you've been looking for! The Wagner "48" capacitor-start motor with either resilient or welded rigid base. You get the standard 48 frame size, with from *three to eight pounds less weight per motor* than previous models of the same hp ratings!

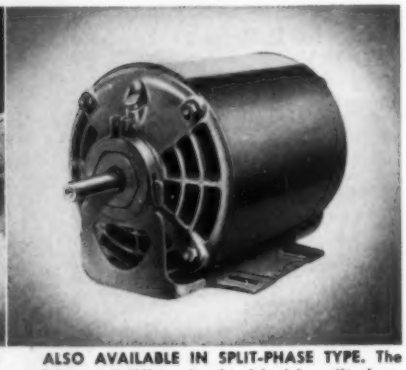
The Wagner "48" is rugged enough to permit direct mounting, compact enough to fit in tight spots, will operate efficiently when mounted at any angle. Through ventilation assures cool operation that adds to motor life.

If you would like to test the Wagner "48", one of our field engineers will be glad to furnish a sample motor. Contact the Wagner Branch near you or write to the factory.

ALL ANGLE OPERATION. You can mount the Wagner "48" at any angle. A new lubrication system assures positive protective lubrication in any position.



EASY TO CONNECT. Just loosen one screw for access to terminal board. **EASY TO SERVICE** . . . no need to disconnect leads when removing endplates.



ALSO AVAILABLE IN SPLIT-PHASE TYPE. The Wagner "48" is also furnished in split-phase type, with resilient or rigid base in ratings of ⅛, ¼ and ½ hp.

Wagner Electric Corporation
SERVING INDUSTRY SINCE 1891

H57-2

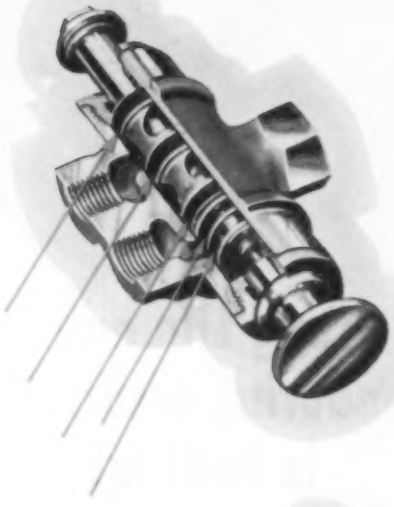
BRANCHES AND DISTRIBUTORS IN ALL PRINCIPAL CITIES

Wagner Electric Corporation
6406 Plymouth Ave., St. Louis 14, Mo., U.S.A.

ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES • AUTOMOTIVE BRAKE SYSTEMS—AIR AND HYDRAULIC

VIX-SYN PACKINGS

meet demands of newest valve design with precise sealing ability ... complete dependability



You see them everywhere—small valves that work under high pressures, all-important control links in new hydraulic and pneumatic systems. They're vital in industry's new trend to automation.

There's one design problem common to almost all these valves . . . getting a seal that's tight, dependable and long wearing, yet allows free valve movement for precise and rapid operation and control.

It's a tough problem, but there's a quick and easy answer in Houghton Vix-Syn "O" rings and packings. You can put them into the most demanding valve designs with complete assurance of dependability, high efficiency in sealing, economy, and long, trouble-free service life.

Houghton developed synthetic rubber specifically to provide design engineers with "O" rings and packings that match the requirements of the newest, most modern valve designs. Call on Houghton, too, for specially molded Vix-Syn parts and compounds. You'll be served by the same packing specialists who set the packing standards industry everywhere uses today.

Ask your Houghton Man for the full story of how Vix-Syn takes the problems out of valve design. Call him today—or write E. F. Houghton and Co., 303 West Lehigh Ave., Philadelphia 33, Pa.

VIX-SYN

. . . a product of

E. F. HOUGHTON & CO.

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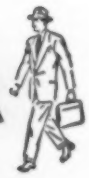

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an ACCO product

Helicoid Gages

Long Life and enduring accuracy is built in!

• Sustained accuracy of HELICOID Gages through years of hard service comes from superior design and construction.

The HELICOID Gage has many unique and exclusive features. It is not only a pressure instrument of the utmost precision but one that requires but a minimum of maintenance throughout a long service life.

The smooth rotation of the spiral movement and cam outlasts and outperforms other gage types. There are no gear teeth to wear out.

HELICOID Gages are available to meet every type of pressure indicating requirement. Ranges are from 15 to 20,000 p.s.i. and vacuum or compound.

Write for catalog today

Why HELICOID Gages last longer!

Socket (1) is one-piece drop forging, streamlined to reduce possibility of clogging.

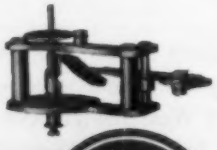
Bourdon tube* (3) is alloy steel, stainless steel or K Monel.

Tube is welded to forged socket (2) and tip (4).

Connecting link and link screws (5) are K Monel.

Helicoid movement (6) is corrosion resistant.

*Phosphor bronze tube also available.



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Helicoid Gage Division
AMERICAN CHAIN & CABLE

929-D Connecticut Avenue • Bridgeport 2, Connecticut

for Better Value

diametral pitch, ranging from 0.75 thru 1.5 in. pitch dia. The overall is 0.562 in., with a choice of 0.1250 or 0.1875 in. bore. Center member is Type 303 stainless steel. Clutch plate is bronze.

Torque setting is attained through the use of an adjustable threaded locking clamp, which can be set to any desired torque reading. Dynamic Gear Co., Inc., 20 Merrick Road, Amityville, N. Y.

For more information—
Circle 77, inside back cover

Mounting Clip for Small Components

The clip is pressed by hand into a mounting hole in a chassis. The desired component is then snapped between the clip's two curved spring fingers where it is held under live spring tension. The clip will accommodate capacitors or similar components with diameters ranging from 0.375 to 1.500 in. Tinnerman Products Inc., Cleveland, Ohio.

For more information—
Circle 78, inside back cover

Step Valves

• Of spool type plunger construction, force required to press down plunger

(Continued on page 290)

1. *By installing the line of Diesel Engines that is backed by world-wide sales, service and parts outlets.*

2. *Or by shipping your units—without motors—to almost any spot on earth, letting your customer install one of these diesels (at lower cost to him) at destination point!*

Perkins Diesels are in use in the following 118 countries and regions:

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AFGHANISTAN
ALGERIA
ANGOLA
ARABIA
ARGENTINA
AUSTRIA
AUSTRALIA
AZORES
BAHAMAS
BARBADOS
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BELGIUM
BERMUDA
BOLIVIA
BORNEO
BRAZIL
BRIT. CAMEROONS
BRIT. GUIANA
BRIT. HONDURAS
BRIT. N. BORNEO
BRIT. SOMALILAND
BURMA
CANADA
CEYLON
CHILE
CHINA
COLOMBIA
COSTA RICA
CUBA
CURACAO
CYPRUS
CZECHOSLOVAKIA
DENMARK
DOMINICA
ECUADOR
EIRE
EGYPT
FED. MALAY STATES
FINLAND
FIJI ISLES
FRANCE
FR. CAMEROONS
FR. EQUAT. AFRICA
FR. GUINEA
GERMANY
GIBRALTAR
GOLD COAST
GREECE
GUATEMALA
HAITI
HOLLAND
HUNGARY
ICELAND
INDIA
INDONESIA
ITALY
IRAQ
JAMAICA
JAPAN
KENYA
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LIBYA
LUXEMBOURG
MADAGASCAR
MADEIRA
MALAYA
MALTA
MAURITIUS
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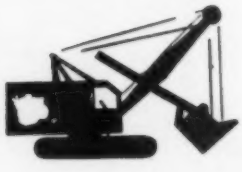


Perkins produced over 4,500,000 brake horsepower in light, high-speed diesel engines in 1955. 70% of this output went into the world markets—where Perkins Diesels set the world standard in motors up to 120 B.H.P.

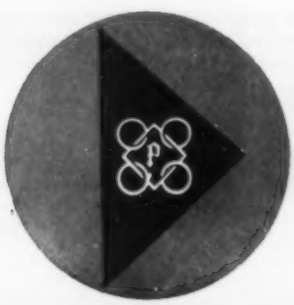
The heavy export units you produce may be the finest of their kind. But unless you can guarantee adequate service and parts facilities on a world-wide scale for the diesel engines that power those units, world markets may be hesitant to buy them.

That is why F. Perkins Ltd. believe they can help you sell more export machinery. Perkins not only make a complete line of high speed, light weight diesel engines—they have sales, service and parts outlets in 106 countries as well! (See list on this page)

Also, these versatile engines are available to specifications of your own engineering department. Deliveries can be made from Sterling sources to you or direct to your overseas branches or distributors.

Perkins maintain an engineering staff in Toronto, Canada to work with your company. Simply phone them. They will fly down to discuss applications with you. Prototype installations can be made at Toronto or at your plant.

Make sure of expert diesel service and availability of engine parts for all your export units . . . cut shipping costs and assembly headaches . . . call Perkins Toronto Office today.



Perkins

F. PERKINS (CANADA) LTD.
wholly owned subsidiary of
F. Perkins Ltd., Peterborough, England

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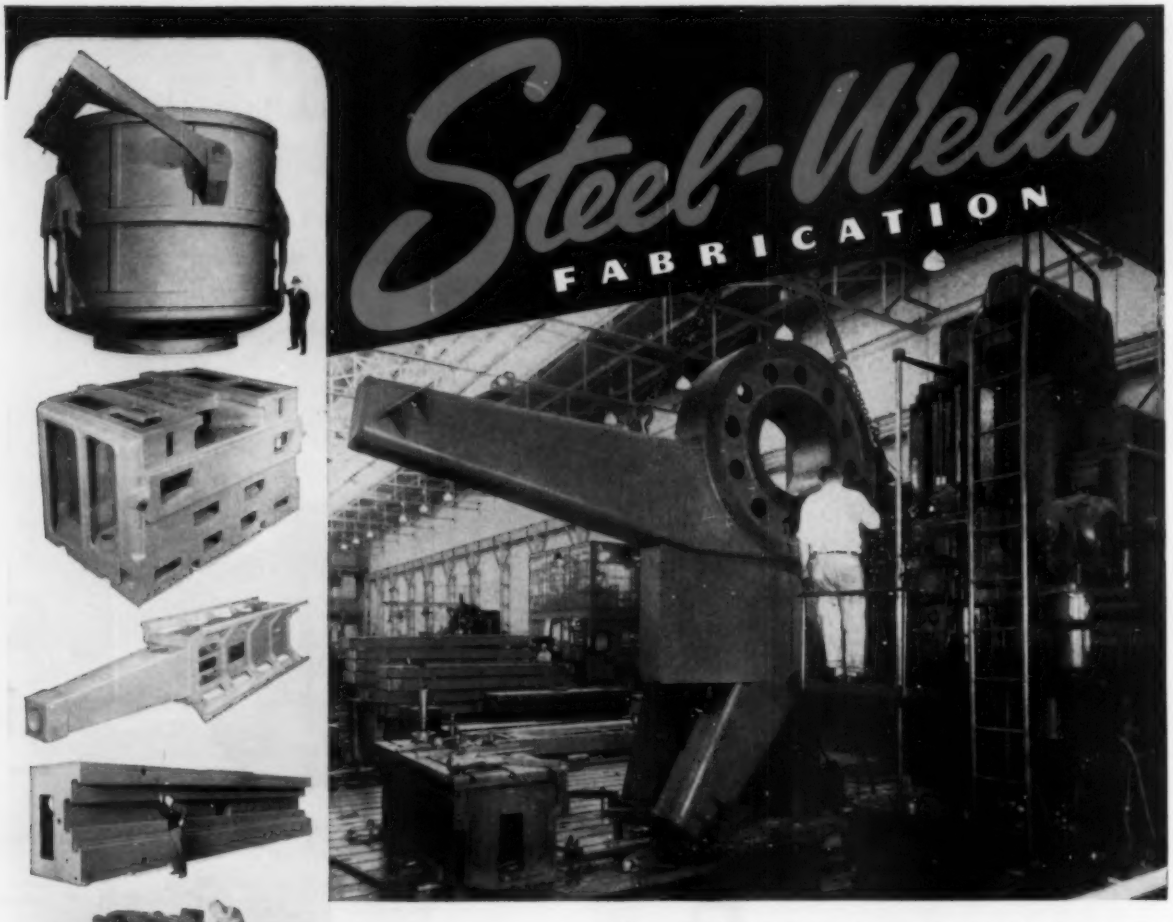
Steel-Weld FABRICATION



Use WELDED STEEL for Greater Strength with Less Weight!

Being machined above is one of 164 Tripods produced and machined by Mahon for use in the world's largest continuous grinding and polishing machine to be employed in the production of plate glass. Weldments, in almost any type of heavy machinery give you greater strength with less weight—and the additional advantages of greater rigidity and predictability. If you can use weldments in your products, you can turn to Mahon for complete service including design, or redesign, fabrication, machining and assembling. The parts and assemblies illustrated here are typical of thousands of Steel-Weld Fabricated units produced by Mahon for manufacturers of processing machinery, machine tools, and other types of heavy mechanical equipment. You, too, will find in the Mahon organization a unique and reliable source for welded steel in any form . . . a source with unusual facilities where design skill and advanced fabricating techniques are supplemented by craftsmanship which assures you a finer appearing product embodying every advantage of Steel-Weld Fabrication. See Sweet's Product Design File for information, or better still, have a Mahon sales engineer call at your convenience.

THE R. C. MAHON COMPANY • Detroit 34, Michigan

Sales-Engineering Offices in Detroit, New York and Chicago

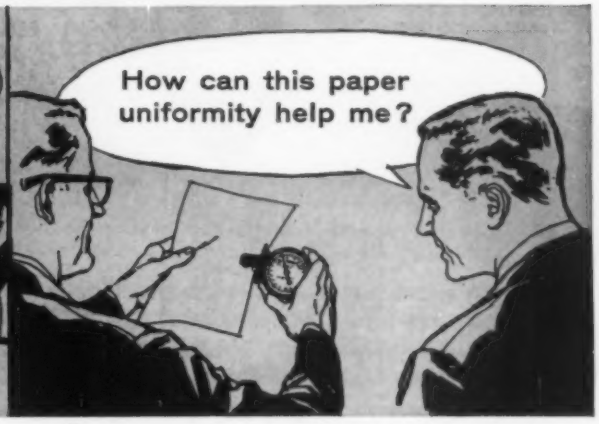
Engineers and Fabricators of Steel in Any Form for Any Purpose

MAHON

A design engineer learns the profit story about special-purpose papers

1 Yes. Mosinee manufactures a special interleaving paper to protect stainless steel's mirror-like finish as it is wound into coils.

2 It is free of corrosive and abrasive materials. This specialized paper is carefully formed and surfaced to avoid marking or scratching.



3 An accurately controlled paper is a better insurance against damaging your product than one not specially engineered for this particular purpose.

4 Yes. Mosinee prepares hundreds of special papers...and every roll meets exact specifications.

For details relating to the added profits possible with Mosinee creative papers, fill out and mail coupon.

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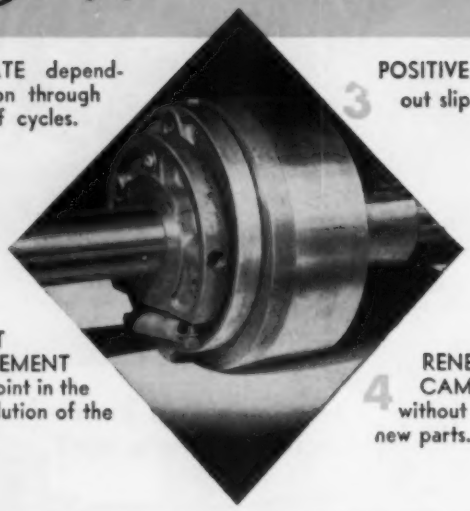
Use this space to describe your product

HILLIARD CLUTCHES FOR POWER CONTROL DESIGNS

HILLIARD
Single Revolution CLUTCH

1 ACCURATE dependable action through millions of cycles.

3 POSITIVE motion without slip or lag.



2 INSTANT ENGAGEMENT at any point in the the revolution of the driver.

4 RENEWABLE CAM SURFACES without machining or new parts.

The Hilliard Single Revolution Clutch *is automation* because it provides precise accurate intermittent motion automatically. Control can be electrical or mechanical.

The use of Hilliard Single Revolution Clutches has improved the operation of tube straightening and cut-off machines—shears—conveyors—riveting and fastening units—case loaders—bottle unscramblers—weighing and packaging—indexing and feeding—marking—punching—textile and business machines—radar apparatus—proportionate pumps—and many other types of mechanisms.

WRITE TODAY FOR BULLETIN 239 WITH COMPLETE INFORMATION.

• OTHER HILLIARD CLUTCHES •

CONSIDER AUTOMATION - INVESTIGATE THESE PRODUCTS

HILLIARD - TWIFLEX CENTRIFUGAL COUPLING for smooth, easy starting of any load automatically with overload protection and ability to accommodate shaft misalignment. Ask for Bulletin CE-3.

OVER-RUNNING CLUTCHES for automatic instantaneous engagement and release on two speed drives, dual drives and ratchet or backstop action. Ask for Bulletin 231.

SLIP CLUTCHES for overload protection, or constant torque and to provide constant tension and permit speed variation on rewind stands. Ask for Bulletin 300.

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MANUFACTURING CLUTCHES FOR OVER 50 YEARS

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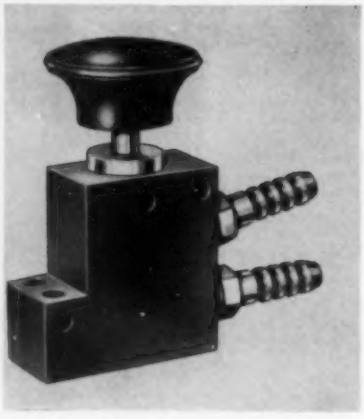
IN CANADA: UPTON • BRADEEN • JAMES, LTD.



is 8¾ lb with increase in line pressure of 30 to 120 psi. Hose nipples are at an angle to accommodate quick connectors and large diameter air hose.

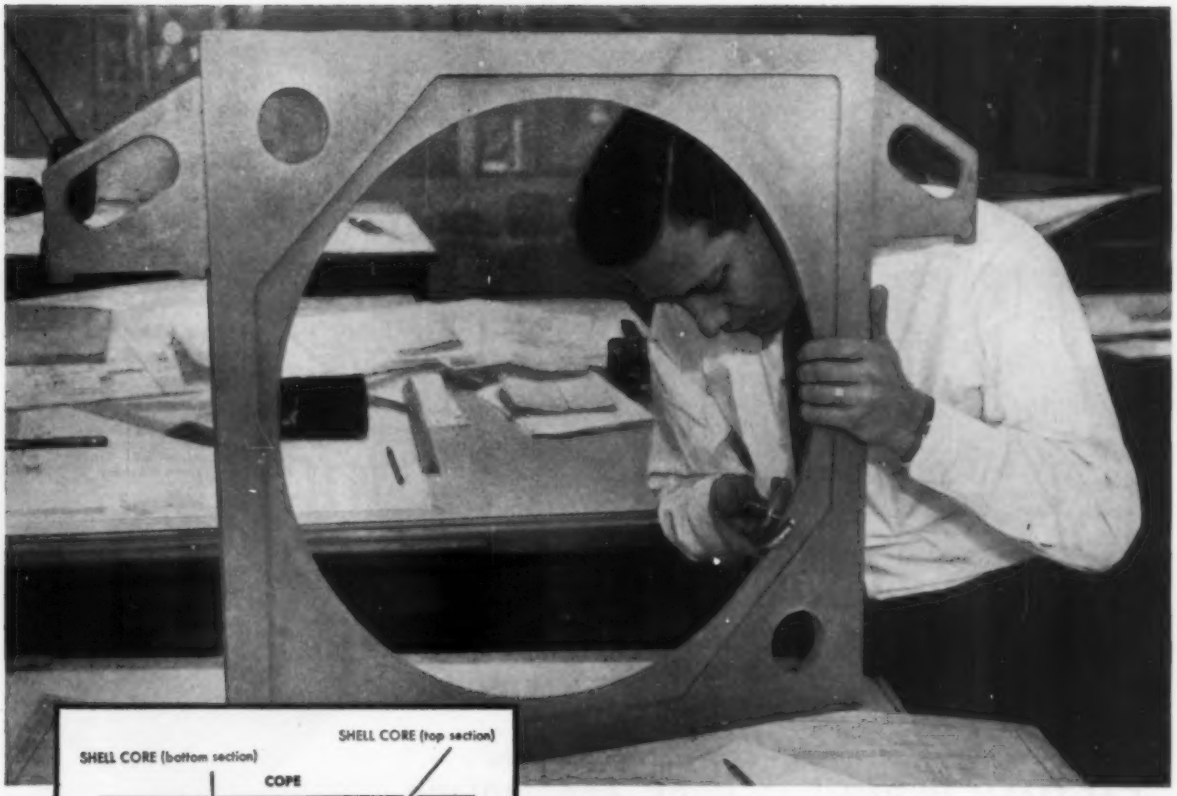
Valve bodies are machined from aluminum; plungers are chrome-plated steel; caps, plugs and hose nipples are brass. Valves can be furnished in either spring return or self-locking type, normally closed or normally open. Mead Specialties Co., Dept. SV-44, 4114 N. Knox Ave., Chicago 41, Ill.

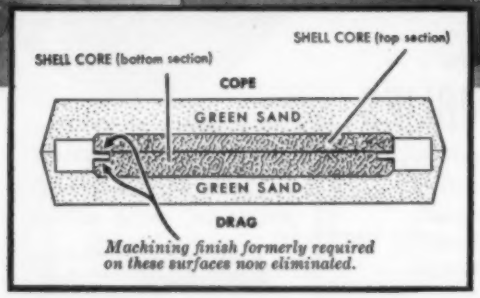
For more information—
Circle 79, inside back cover

Electronic Proximity Control

This control detects the presence of an insulator or conductor at the detecting point without making contact with the surface. It can be used as a limit switch which does not require physical contact with the controlling surface. The unit can be used as a level control of such materials as soap, coal, oil as

(Continued on page 294)





CAST TOLERANCE OF ±.015" HELD in stainless steel filter plate web

Costly milling operation now eliminated by Cooper Alloy precise-dimension casting. Here's how it cut Tennessee Eastman's costs . . .

PROBLEM: To cast these filter plates in one piece (26" x 26" sq.) with the thickness of the center web held to .310" ± .015". Deviations from this tolerance would result in improper seating of filter cloths. Normal sand casting methods could not produce the required accuracy.

SOLUTION: To secure the precise dimensions required for the inner "web", Cooper Alloy placed a special shell core *inside a greensand mold*. When closed, space between the shells provides precisely uniform thickness, and surface of shell assures a superior finish.

Today, thanks to Cooper Alloy "Advanced Casting Know-How", this piece, using one of the largest shell cores ever made, is being successfully produced in quantity by Cooper Alloy. It saves Tennessee Eastman hours of machining time and thousands of dallors in finished-piece costs.

Cooper Alloy, a specialist in stainless steel for 35 years, is still a pioneer in the development and application of new techniques for handling this tricky metal. Next time *you* have a tough problem, and there's a chance that a unique casting method can save time and money, talk to Cooper Alloy.

COOPER ALLOY

Corporation • Hillside, New Jersey

FOUNDRY PRODUCTS DIVISION

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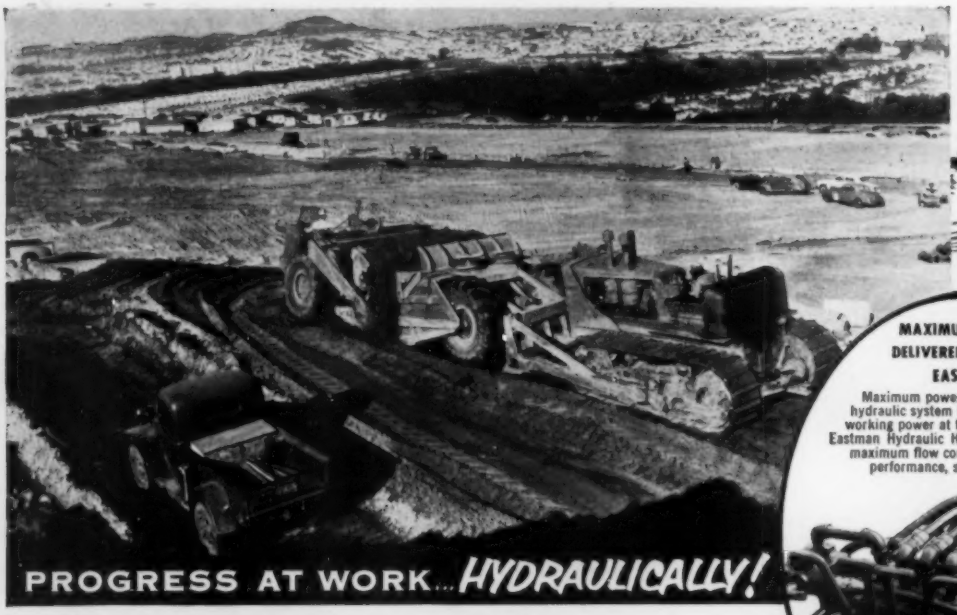
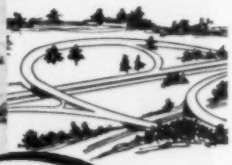
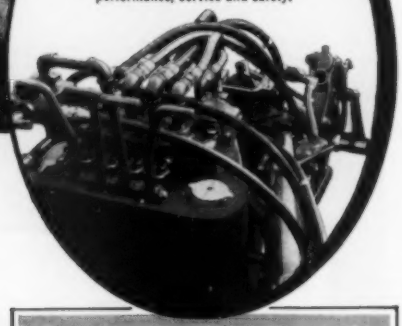


America's Future Lifeline of Travel



MAXIMUM POWER DELIVERED THROUGH EASTMAN

Maximum power delivery for every hydraulic system is the key to efficient working power at the point of operation. Eastman Hydraulic Hose Assemblies provide maximum flow consistent with efficient performance, service and safety.



SMOOTHER AND SAFER ROADS ARE BEING BUILT FASTER... THROUGHOUT AMERICA *with*

HYDRAULIC POWER delivered thru

EASTMAN HYDRAULIC HOSE ASSEMBLIES

Modern Hydraulics will put millions of horsepower to work building America's roads . . . maneuvering mighty earth-moving machines with finger-tip ease. Grading, loading, leveling and finishing will be easier, more economical—saving time, money and manpower.

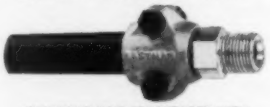
Many Pioneer Manufacturers of modern road building equipment have, from the beginning of hydraulics—equipped their machines with Hydraulic Hose Assemblies made by the very first pioneer manufacturer in this field—EASTMAN of Manitowoc, Wisconsin.

Eastman's Continued Leadership has been maintained through advanced engineering and design—plus materials and workmanship which are so high that they are accepted by many Original Equipment Manufacturers as the *standard for the industry!*

Eastman Is Geared to supply the critical demand for performance-tested Hydraulic Hose Assemblies which will more than meet the roughest road building construction hazards. Many 'round the clock operations will now run into year-'round schedules, and Eastman's new production facilities stand ready to provide *dependable shipments, service and satisfaction.*

FOR INCREASED EFFICIENCY IN HYDRAULIC POWER *Specify* EASTMAN HYDRAULIC HOSE ASSEMBLIES

EASTMAN'S NEW "HI-FLO" COUPLING DELIVERS A MAXIMUM OF POWER



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CUT COSTLY "DOWN-TIME" WITH EASTMAN RE-USABLE COUPLINGS

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BULKHEAD "O" RING ADAPTERS, HYDRAULIC TUBE FITTTINGS, UNIONS, ELBOWS, "O" RING ADAPTERS AND LOCKNUTS FOR ALL HOSE ASSEMBLIES, RE-USABLE COUPLINGS

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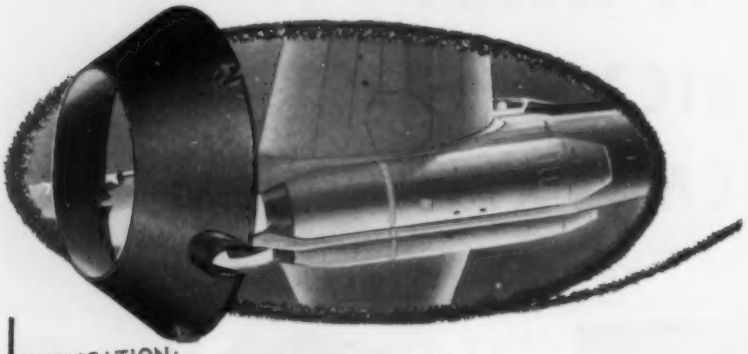
THE SHAPE OF THINGS IN MOLDED SILICONE

SILI-CONE PROVES REAL COOL FOR JET AIRCRAFT EQUIPMENT



APPLICATION:
Thermal barrier for jet aircraft accessories.

PROBLEM:
The original part, along with drawings and molds, was presented to Acushnet by a well-known manufacturer of accessories for conventional and jet aircraft with orders to continue development with Dow-Corning 301 compound. The idea was to attain a part that would provide maximum physical properties at elevated temperatures of over 800°F.

SOLUTION:
Overcoming the high bulk factor of the compound was accomplished through the design and construction of a preform. Running the original mold in a special hydraulic ram equipped with controls permitting a wide range of temperatures and pressures, provided the necessary information in curing this compound. The resultant cure times and pressures enabled Acushnet engineers to design and construct a compression mold of hardened steel that made this part possible. Included in this project were small gaskets molded from Dow-Corning 301 that proved superior to metal in high heat insulating applications.

Pioneers in the advanced mold techniques and custom compounding of silicones, Acushnet now offers you immediate technical assistance in the molding and finishing of silicone resins.

Send for Acushnet "Silicone Rubber Brochure"

What's Your Shape?

Acushnet

ACUSHNET PROCESS COMPANY
NEW BEDFORD, MASSACHUSETTS
••• *Precision Molded* RUBBER, SILICONES - "APCOTITE" BONDING
Address all communications to 768 Belleville Ave., New Bedford, Mass.

an interface control between two dissimilar fluids.

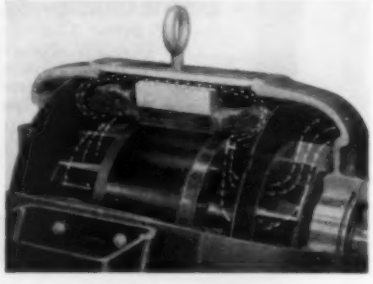
Input voltage is 115 v, 60 cps. Line consumption is 25 va, relay capacity 5 amp, 115 v, contact available is single-pole, double-throw. Machinery Electrification, Inc., Northboro, Mass.

For more information—
Circle 80, inside back cover

Synchro Accurate to 3 Min

These units were designed for control and data transmission systems and servo mechanisms. In many instances, they are said to eliminate two-speed synchro systems. Norden-Ketay Corp., Commerce Road, Stamford, Conn.

For more information—
Circle 81, inside back cover



Re-rated Motors

Re-rated to conform with new requirements established by NEMA, elimination of "hot spots" is accomplished by straight-through, dual-sweep ventilation. Tandem fans, one pushing and another pulling, produce a wash-

(Continued on page 296)

TDA® BRAKES

if it rotates...we can control it!

new "DM" brake

...farm equipment
...special duty utility trailers
...lightweight highway trailers
...industrial machinery

"DM" DUPLEX MECHANICAL BRAKE

Best on many jobs, this rugged new DM Brake actually outperforms more specialized brakes. It has proved its worth with farm equipment, special duty utility trailers, light duty highway trailers, industrial machinery, and in a wide variety of special applications.

Greater torque output! The DM Brake is a self-energizing, balanced type . . . the two identical shoes do an equal amount of work in either forward or reverse direction.

Simpler Maintenance and Adjustment!

The DM Brake is wedge-actuated through an easily accessible operating lever, giving positive braking with immediate response. The DM Brake can be actuated by either an air or hydraulic cylinder, or mechanical means. Complete accessibility permits quick, easy adjustment. Simple design keeps maintenance and service at a minimum.

TIMKEN Detroit BRAKES
ROCKWELL SPRING AND AXLE COMPANY
Accepted TDA Standard

For every industrial, agricultural or automotive application where braking is required!

TDA Plants at: Detroit, Michigan • Oshkosh, Wisconsin • Utica, New York
Ashtabula, Kenton and Newark, Ohio • New Castle, Pennsylvania

Timken-Detroit Brake Division
Rockwell Spring & Axle Company
Dept. PE-17, Ashtabula, Ohio

Please send me further information on your "DM" Series Brake.

Name _____ POSITION _____

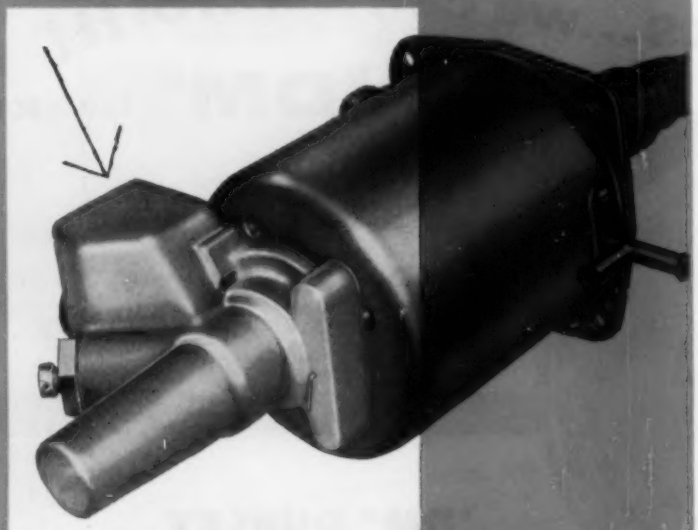
Company _____

Address _____

City _____ State _____

Zincilate

when ordinary protective coatings won't do!



Zincilate #611 meets all requirements of Spec. MIL-P-26915 (USAF)

In producing power boosters for master brake cylinders, ordinary protective coatings just won't do. If the coating is applied *before* the part is machined and fabricated, it breaks down during processing and there's no more protection. If it's applied *after* processing, then there's the tedious, costly job of masking off the uncoated areas on each piece. Another problem—every power booster must be immersed in diacetone to check for leakage—and the ordinary coating simply disappears upon contact with diacetone.

These are the kind of problems that require an outstanding protective coating—Zincilate. A quick whisk of a spray gun and each power booster is now coated—before machining and fabricating—with Zincilate #611 (one of several Zincilate formulations). There's no time wasted in masking off, and no amount of processing, even including clamping in a vise, will break down Zincilate's lasting, thorough protection. And about that testing for leakage—not even diacetone can pry Zincilate #611 loose!

When results, not mere first cost alone, are paramount, designers and producers of the finest metal products turn to Zincilate for the solution to protective coating problems. If you'd like more information on Zincilate, just outline your problem, on your company letterhead please, and we'll tell you frankly just what Zincilate can do for you.

Zincilate

CORROSION-RESISTANT, ABRASION-RESISTANT, WELDABLE, AIR-DRIED and BAKED PROTECTIVE COATINGS

INDUSTRIAL METAL PROTECTIVES, INC., 404 HOMESTEAD AVE., DAYTON 8, OHIO

ing action. Mylar, laminated to rag paper, is used as slot cell insulation. Removable cover plates on each end-head permit inspection without dismantling the motor. Numbers are permanently impregnated into the subsurface of lead insulation. One-piece, shrouded end-heads give the motors full height protection against moisture and falling objects. Internal baffles complete the splash-proof construction. Factory-installed end-head screens are included at no extra cost. Robbins & Myers, Inc., Springfield,Ohio

For more information—
Circle 82, inside back cover

Sector Potentiometer

These potentiometers are designed to measure angles from zero to a maximum of 90 deg of shaft rotation. Accuracy of 0.5 per cent is claimed, resolution to 0.10 deg. The instruments are capable of withstanding up to 300 F. Humphrey Inc., 2805 Canon St., San Diego 6, Calif.

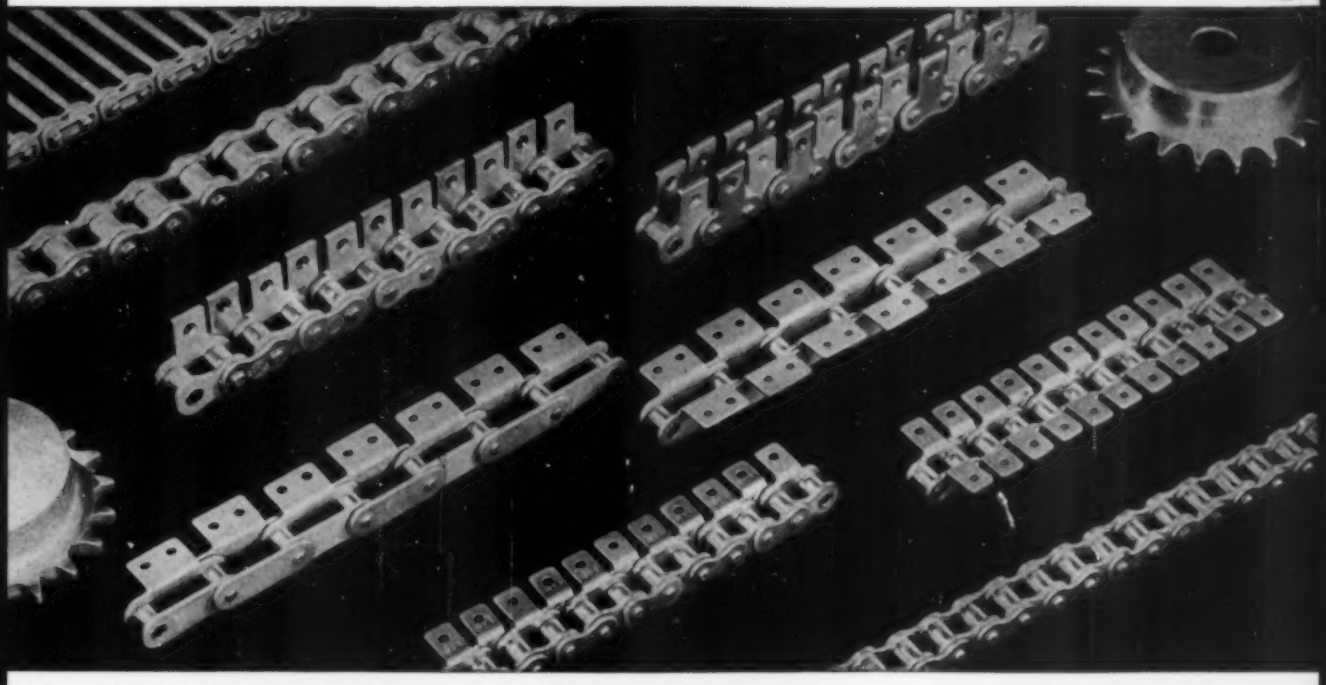
For more information—
Circle 83, inside back cover

Hydraulic and Pneumatic Cylinder

A complete line of $\frac{3}{8}$ in. bore cylinders provide single and double action. Pressure rating is 150 psi air and 750 psi oil. Mounting style available includes universal (foot and/or flange), clevis, trunnion. Brass heads, brass or steel barrels are standard. A

(Continued on page 298)

it's NEW! it's Revolutionary it's Electrolized!



ATLAS ROLLER CHAIN

CORROSIVE RESISTANT...COSTS 40% LESS
COMPARATIVE TESTS PROVE IT WEARS 100% LONGER

From coast to coast manufacturers, engineers and transmission drive specialists are acclaiming this as the most revolutionary development in the roller chain field. It meets the most exacting requirements of the chemical, food, beverage and other industries where corrosion resistance is a factor. Yet it has been tested and proved to outlast, outrun and outwear other chains even though it costs far less.

HIGHER TENSILE STRENGTH—has same tensile strength as alloy steel chain . . . much higher than bronze or stainless steel chain.

LONGER WEARING—actual wear-drive tests prove it lasts as much as 100% longer than alloy steel chain.

STAINPROOF, CORROSIVE RESISTANT—corrosion resistance is greatly increased in Electrolized Chain and compares favorably with any other corrosion resistant chain now on the market.

LOWER PRICE—of Atlas Chain makes it as much as 40% less in cost than any other corrosion resistant chain now on the market.

Here's the chain that makes it possible for you to re-evaluate the specifications of your transmission drives. From the standpoint of cost, efficiency and longer wear it allows you to specify corrosion resistant chain on drives previously ruled out due to high cost and short chain life.

You owe it to your plant to contact your nearest Atlas distributor to get the complete story on Atlas Electrolized Roller Chain and Sprockets. He can help you attain a new standard of efficiency on your transmission drives.

ATLAS CHAIN AND MANUFACTURING CO.
West Pittston, Penna.

GET THIS DATA ON ELECTROLIZED CHAIN

This free brochure tells you in brief question and answer form all about Electrolized Chain. Write for your copy today.

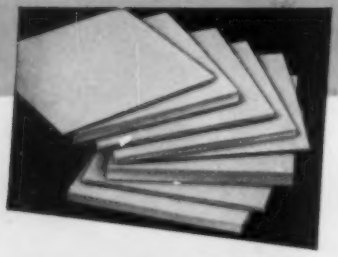
TEFLON*

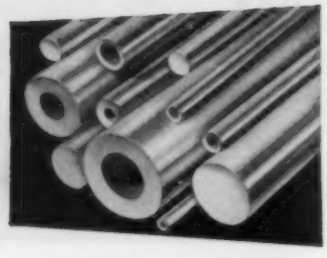
SHEET....ROD....

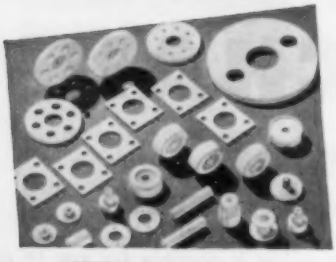
TUBING....MOLDED OR MACHINED PARTS?

YOU CAN GET JUST WHAT YOU WANT

from JOHN CRANE







"Made of Teflon by JOHN CRANE" has become practically a standard specification for parts and components subject to severe electrical, corrosive, thermal, mechanical or atmospheric abuse. Whatever your requirements in Teflon . . . sheet, rod, tubing, packings, gaskets, bellows, insulators, sealing discs or non-stick parts . . . "John Crane" can supply them!

In addition, you get these important *plus* factors: complete uniformity throughout, high density control, freedom from flaws and rigid adherence to your specifications.

"John Crane's" complete fabrication facilities assure you prompt delivery on *exactly* what you want —no compromise. If you have an entirely new requirement, no standard design or procedure— "John Crane's" laboratory facilities, know how, research and engineering experience go to work on *your particular* need.

Now is a good time to put "John Crane" to test. Contact Crane Packing Company today.

*TEFLON *DuPont trademark*

Advantages:

CHEMICAL—Completely inert

ELECTRICAL—Extremely low power factor
Very high dielectric strength

THERMAL—Temperature range
—300°F. to +500°F.

MECHANICAL—Strong, flexible
Weather resistant

LOWEST COEFFICIENT OF FRICTION

ABSOLUTELY NON-STICK

Crane Packing Co.,
6445 Oakton St.,
Morton Grove, Ill.,
(Chicago Suburb).
In Canada: Crane Packing Co., Ltd., Hamilton, Ont.

JOHN CRANE CRANE PACKING COMPANY

38 YEARS INDUSTRIAL PROGRESS

OFFICES IN ALL PRINCIPAL CITIES

honed stainless steel piston rod and chevron rod packing are used. Airoyal Co., 1990 Springfield Ave., Maplewood, N. Y.

For more information—
Circle 84, inside back cover

Pressure Switches

Specifically designed for aircraft, these switches are for switching electrical circuits in response to pressure changes in gases, liquids and atmosphere. They will perform in any position.

The switches are available in two sizes; regular size for pressures between 5 and 150 psi, and miniature size for pressures of from 2 to 100 psi, each in absolute, gage, or differential as specified. Contact ratings are 5 amp or 10 amp at 30 v d-c or 115 v a-c. Normal ambient operating temperature range is —65 F to 250 F. They are hermetically sealed. Bristol Co., Waterbury 20, Conn.

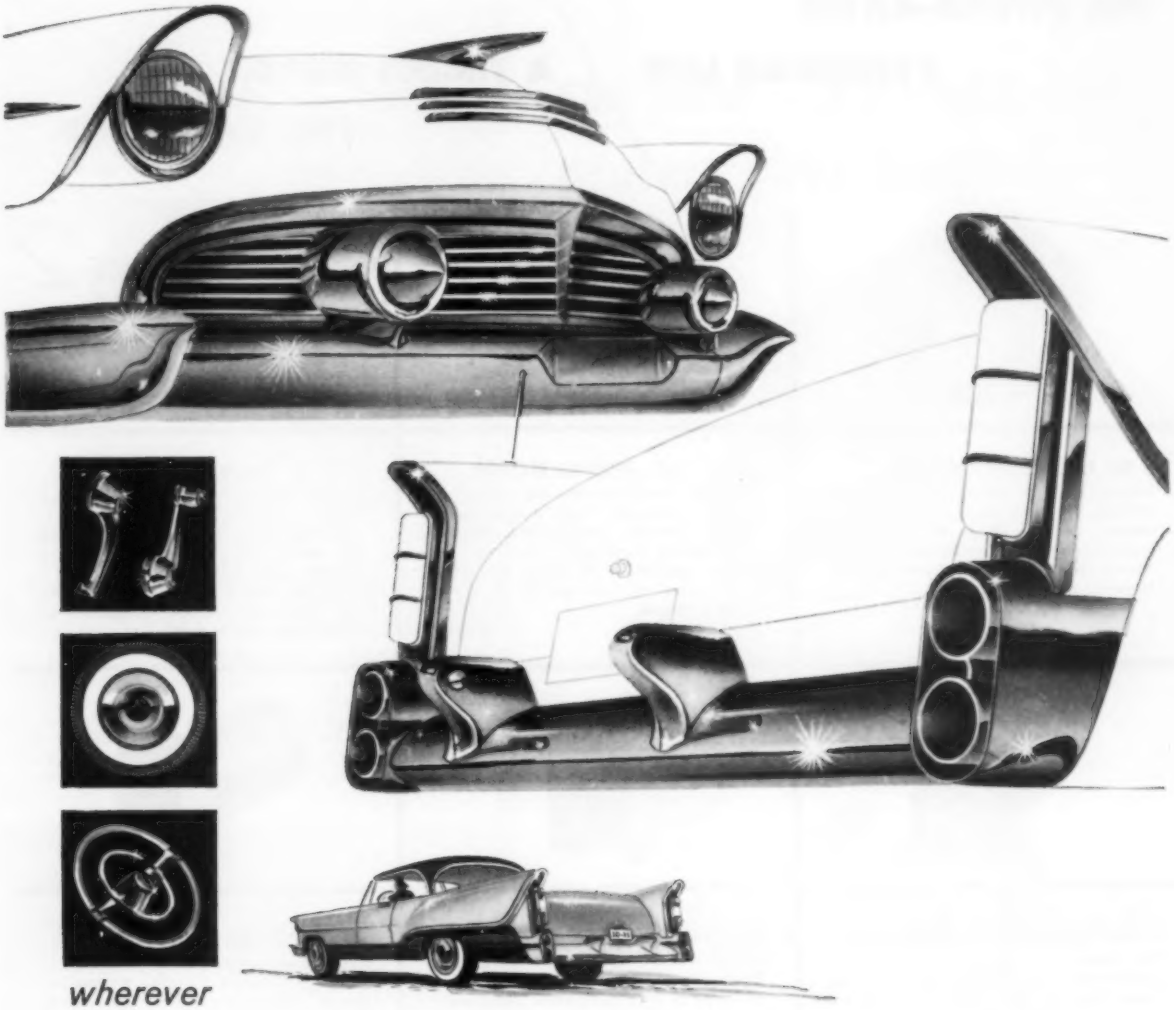
For more information—
Circle 85, inside back cover

Single or Double-Wound Relays

Variations in contact arrangements and contact materials are available in these relays. Coils available include single or double-wound, time delay slugs, and special windings for high temperature and/or high humidity.

Armature is fixed to a precision-ground stainless steel pin, which turns

(Continued on page 303)



wherever you add trim . . .

THEY'LL PREFER STAINLESS!

it's a metal they know!

Sporting goods, jewelry, appliances, fine cutlery — yes, even the car they're trading in — all these things have shown them the strength, beauty, permanence, and remarkable cleanability of stainless steel.

You'll like stainless, too. It needs no protective coating. It helps simplify production and increases design flexibility through an unmatched combination of advantages — beauty (complemented by a wide variety of finishes), fabricating ease, remarkable structural strength, and great resistance to all weather conditions.

Let a Crucible engineer show you how stainless steel pays its way. *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

CRUCIBLE first name in special purpose steels

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Canadian Distributor — Railway & Power Engineering Corp., Ltd.

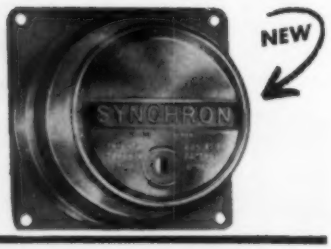
THE POWER-RATED SYNCHRON LINE / A TIMING MOTOR FOR EVERY JOB

8 IN. OZ. TIMING MOTOR

Widely used in timing machines, time switches, heating and air conditioning controls, action signs, recording thermometers, and other timing devices. Guaranteed to pull 8 in. oz. direct load continuously at 1 r.p.m.

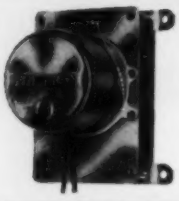
20 IN. OZ. TIMING MOTOR

Ideal for timing motor applications requiring continuous high torque power. Instant starting, dependable accuracy, and flexible installation. Call for Synchron's guaranteed 20 in. oz. at 1 r.p.m. power when your job calls for long, continuous torque.



1 R.P.H. TIMING MOTOR

Guaranteed to pull 20 in. oz. at 1 r.p.h. (1/60 r.p.m.) Synchron's especially developed motor for slow motion timing applications. Eliminates need for extra reduction gears between 1 r.p.m. and 1 r.p.h. in intermittent time trains. Gives gear train with lifetime lubrication; enclosed and trouble-free.

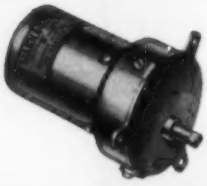


SYNCHRON TIMING MACHINES

An almost unlimited number of shaft speeds. Synchron Motor fixed to a rigid frame. Easy to mount and connect in any position. Trouble-free, accurate. Drives everything from liquid recorders to program clocks and washing machine timers. Highlights complete versatility of famed Synchron Line.

SYNCHRON CLOCK MOVEMENTS

For standard and office clocks, sign clocks, novelty clocks, and clocks of all kinds up to 26" in diameter under glass. Split-second accuracy and long wearing construction, never needs oiling. Furnished with front, rear or bottom set, with or without dustproof case.



MAGNA-TORC D.C. MOTOR

Designed originally for use in aircraft instruments and radio control mechanisms. During World War Two the Hansen Magna-Torc proved its rugged dependability in all altitudes and in all climatic conditions. Now this motor is being adapted to many commercial applications.

"Workhorse of the industry"

*Synchron synchronous motors operate smoothly, evenly in any position; at temperatures from —40° to +140°F.; start instantly under load; pull up to 20 in. oz. at 1 RPM. Available in 42 speeds from 0.8 RPM to 600 RPM.

Synchron timing motors in all speeds available for prompt delivery

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SYNCHRONOUS MOTORS, TIMING MACHINES, CLOCK MOVEMENTS, MAGNATORC D.C. MOTORS

HANSEN MFG. CO., INC.

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Princeton 5, Indiana

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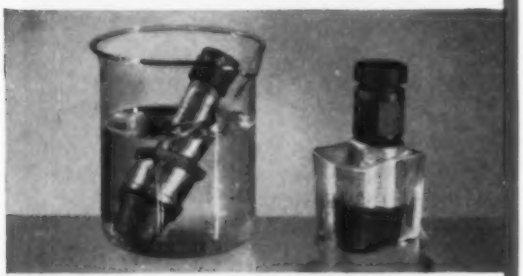
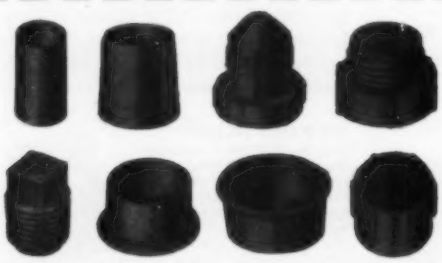
SEE HOW EASY THEY SLIP ON, AND OFF!
Tapered (non-threaded) CaPlugs can be used as caps or plugs, inside or outside of threaded or plain fittings. Threaded styles are knurled to spin on or off with ease. Costing less to buy, they cost less to apply.



SEE HOW THEY WITHSTAND ACIDS, SOLVENTS, HEAT AND COLD... and keep out dust and moisture, too. Dunk a CaPlugged product in any solution. Subject it to actual process conditions and temperatures. Made of tough, flexible Polyethylene, CaPlugs are impervious to most common chemical reagents, acids and solvents ...retain form stability under stress at temperatures from -94°F. up to 175°F.

SEE HOW TOUGH THEY ARE. For proof, drop a product on its CaPlug...tap it with a mallet...or make a trial shipment of parts with CaPlugs applied. You'll find that these versatile closures provide "kid-glove" protection and will not collapse, chip, break or shred under the most severe of conditions.



SEE HOW EASY IT IS TO GET CaPlugs THAT FIT. By mailing the coupon, you'll receive a free sample of each of the ten different styles which are available in a combined total of over 300 stock sizes. There's a CaPlug that's *right* for practically any closure need. You name it! "Off-the-shelf" deliveries from a 30,000,000 inventory can be made to answer immediate requirements promptly.

see how CaPlugs can protect your products

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by testing a free sample assortment like this

YOU'RE INVITED TO TEST CaPlugs in any way you choose. The coupon below will bring a random assortment to your desk...plus illustrated literature, complete details and prices. Reasonable quantities of additional samples in specific sizes for testing are also yours for the asking (details in literature).

MAIL THIS COUPON FOR FREE BOX OF CAPLUGS, DETAILS AND PRICES

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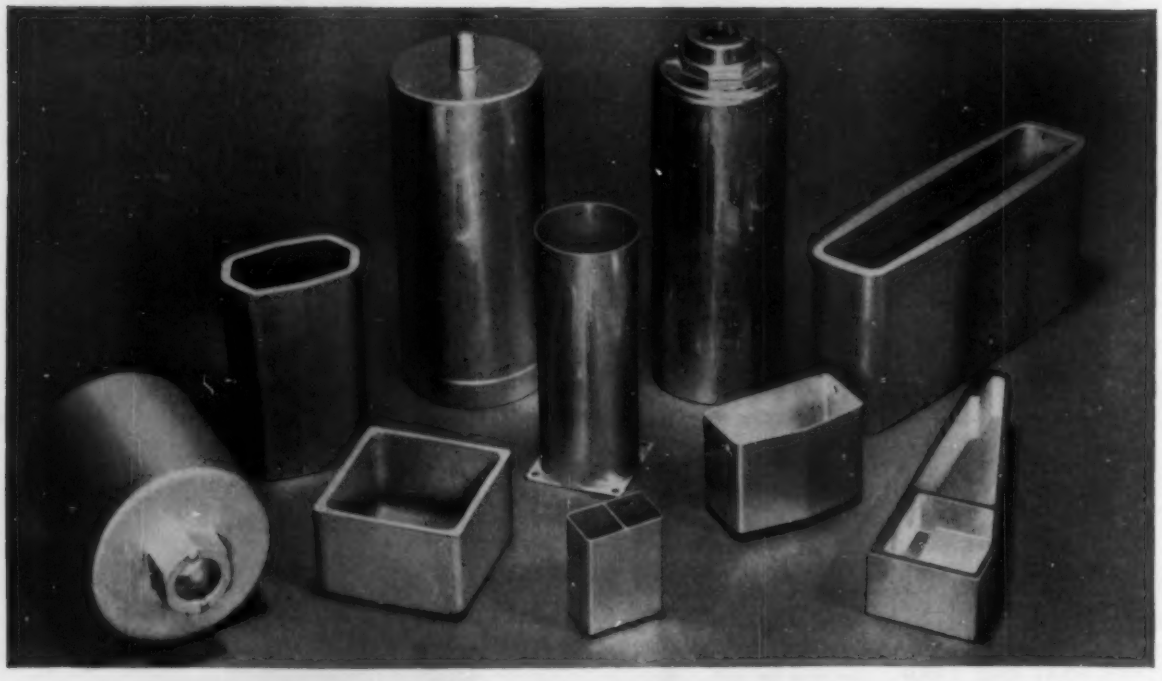


SIMPLIFY DESIGN, GAIN SUPERIOR STRENGTH!

Specify Hunter Douglas Aluminum Impacts

Hunter Douglas Aluminum Impacts are solving a lot of important design problems in all types of industry. Here are quick answers to everyday questions.

HOW DO IMPACTS DIFFER FROM COLD FORGINGS? Basically, only in material used. "IMPACT EXTRUSIONS" are thin walled components extruded from 2S or *soft material*. "COLD FORGINGS" are thick walled shapes made from *heat treatable* aluminum alloys. For simplicity, we'll consider both synonymously.

HIGH STRENGTH—You will find all the properties of forged structures in impacts—exceedingly dense, fine grain, strength and toughness with unusual freedom from porosity and internal flaws...a natural for *high pressure applications*, either gas or liquid. In impact extrusions, flow lines actually follow part contours, adding extra strength. Often strength is satisfactory as extruded, without subsequent heat treatment. Our new alloy, HDX, gives tensiles as high as 85,000 psi with minimum yield strength of 80,000 psi for highly stressed applications.

GREATER SIMPLICITY—Complicated multiple piece assemblies can often be replaced with a single impact. An integral impact eliminates mechanical and/or welded joints and results in a smooth surface, unbroken by seams.

MORE DESIGN FLEXIBILITY—Generally, we can put extra metal where it's needed or thin up sections where required... like making bottoms of cans thicker than walls, adding integrally forged cavities or bosses of any shape, internal or external. Fluted or ribbed sidewalls, either decorative or functional, are easily produced by impact extrusions.

TOLERANCES—Hunter Douglas shines on accuracy...holds tolerances as close as ±.005" on specific diameters and matches screw machine tolerances on wall thicknesses.

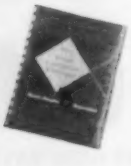
ZERO DRAFT—If you want straight, uniformly thick sidewalls, Hunter Douglas Impacts are for you. Zero draft cuts all unnecessary machining and reduces metal waste. Impacts usually require only trimming, drilling, tapping or minor clean-up.

SMOOTH, BRIGHT SURFACES—There's no scale or rust and surfaces range up to 125 microinches, as extruded...plenty smooth for lithographing or painting without secondary finishing. Real dazzlers result by polishing, satin finishing or anodizing. For extra wear or corrosion resistance anodizing is the answer.

UNLIMITED PART GEOMETRY—We've made impacts round, square, rectangular, triangular, octagonal and most other shapes. We do best if parts are symmetrical along the center axis, but good tooling often solves even a tough design problem. A sketch will enable us to advise or suggest means to an end.

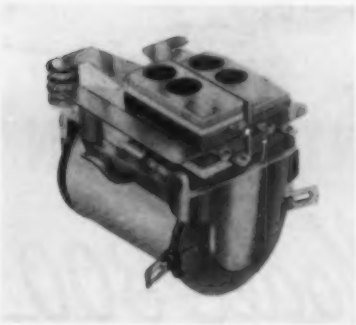
WHERE TO USE IMPACTS—Here are rule-of-thumb considerations: hollow parts with one closed end; walls or surfaces of zero draft; lengths of 6 to 8 times O.D.; strength of hammered or pressed forgings; integral ribs, bosses or webs; tolerances of ±.005"; typical surface finishes of 125 microinches; concentric, multiple diameters.

WE'D LIKE TO HELP—
Our booklet gives valuable impact and cold forging information and our engineers are eager to advise. Simply write on your letterhead we'll do the rest.



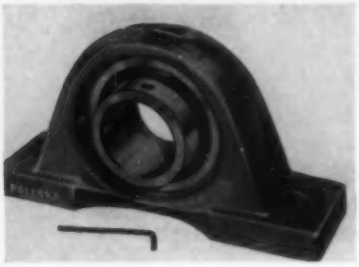
Hunter Douglas Aluminum Corporation

HUNTER DOUGLAS ALUMINUM CORPORATION • DEPT. PE-1, RIVERSIDE, CALIFORNIA • TELEPHONE OVerland 3-3030



in a reamed bronze yoke extending the full width of the relay. The armature backstop is stainless steel for maximum strength and rigidity. Phillips Control Corp., Joliet, Ill.

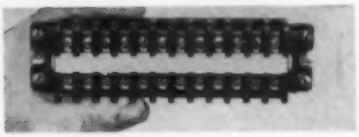
For more information—
Circle 86, inside back cover



Pillow Blocks

This line of pillow blocks, flange units and take ups is available in normal and medium duty series from ½ to 4 in. Rockwood Pulley Mfg. Co., Inc., 20 Crosby St., New York 13, N. Y.

For more information—
Circle 87, inside back cover

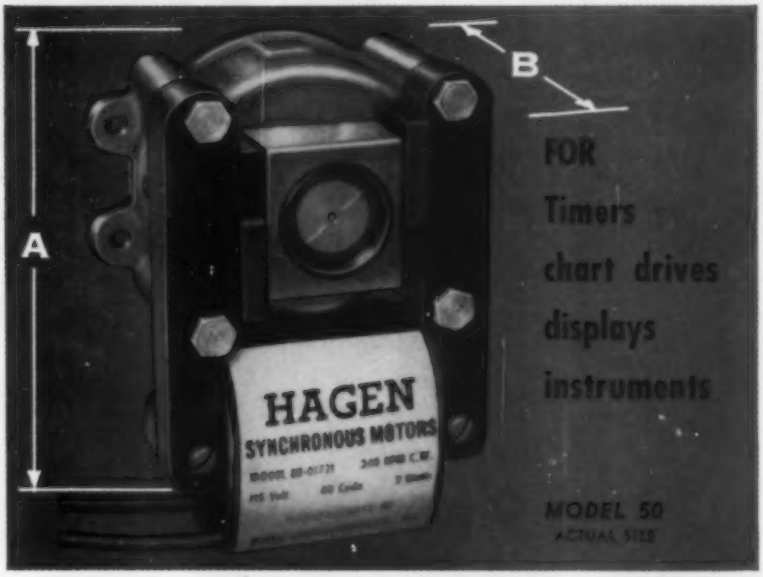


Terminal Blocks

A channel-mounted terminal block is said to provide 50 per cent more terminals in the same space. These blocks are 25 amp box lug-type terminals. Also available in the new design are 25 amp terminals with pressure wire connectors and 50 amp box lug terminals. All three types may be grouped in any manner on the

(Continued on page 306)

HAGEN
Synchronous motors



most powerful for its size

Laminated rotor construction of the Model 50 Hagen Motor produces exceptionally high torque. For example, the rotor develops 10 ounce inches torque at 4 RPM. This motor is ideal for those applications requiring from 5 to 10 times the power of clock-type miniature motors. Yet in spite of its power, the motor is extremely compact:

DIMENSIONS

	50 to 60 cycle	25 cycle
A	3-3/32	3-1/16
B	1-13/32	1-23/32

Just a few of the many possibilities for use are: door chimes, laundry timers, depth finders, animated displays, heating controls, program clocks, fire alarm systems, integrators, time switches, chart drives, scoreboards, potentiometer drives. Motor may be mounted in any position. Wide selection of output speeds from 1800 to 1/6th RPM. Reversible and other models available. Send coupon for Bulletin No. 1055.

MAIL COUPON TODAY

HAGEN MANUFACTURING COMPANY, INC.
Dept. PE-157, Moline, Illinois

Please send Bulletin 1055 on Hagen Synchronous Motors.

NAME AND TITLE

COMPANY

ADDRESS

CITY ZONE STATE

NEW NICHOLSON *Model 300*

"4-way" control valve

Versatile flat-disc type valve is drop-tight . . . provides sensitive throttling action for a variety of rugged control applications.

If you need precise, repeatable control of double-acting cylinder-actuated mechanisms . . . you'll want to try this new advanced-design valve. Ruggedly constructed of a combination of corrosion-resistant materials, it can be used with air, water, gas and oil. Check its features, send for literature.

Send for your copy of new Bulletin 300 . . . for details on design, construction, sizes and applications.

Outstanding features:

- **Trapezoidal ports for modulated throttling.**
- **One-shot lubrication, reservoir in base.**
- **Leak-proof O-ring packing and seal.**
- **Easily adapted to single cylinder control.**
- **Low maintenance, easily disassembled.**
- **Simple, reversible mounting clamp and lugs.**

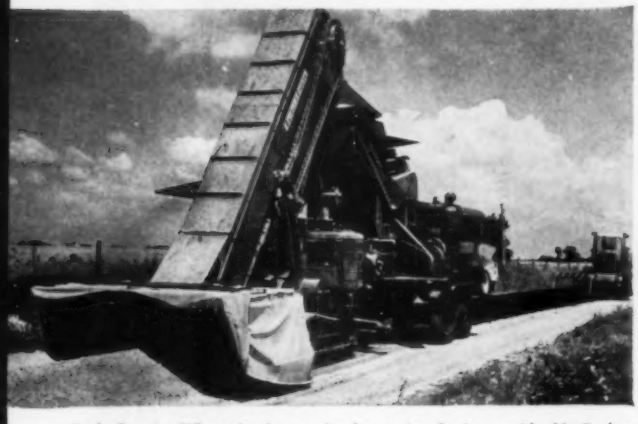
NICHOLSON

W. H. NICHOLSON *and Company*

VALVES • TRAPS • FLOATS • METAL PARTITIONS • LAUNDRY, DRY CLEANING, AND PRESSING MACHINERY • HOSPITAL CUBICLES

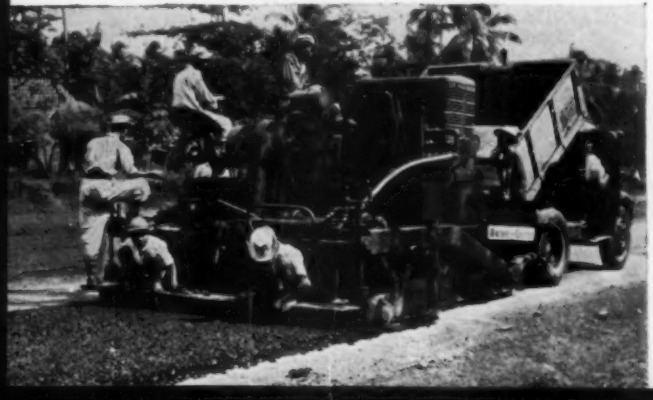
14 OREGON STREET, WILKES-BARRE, PA. • SALES AND ENGINEERING OFFICES IN 98 PRINCIPAL CITIES

An International UD-18A powers the cyclone dust collector and a UD-1091 operates the dryer in this Barber-Greene Model 848 bituminous plant owned by Hallet Construction Company, Ames, Iowa.



Rock County, Wisconsin, is now in the paving business with this Barber-Greene Model 848 Travel plant. Towing loader uses an International UD-350 and the mixer uses a UD-18A.

100% International power units and trucks is the rule for Hazelmore Bituminous Co., Fairmont, Minn. Their Barber-Greene Model 848 continuous-mix plant is powered by a UD-18A and a UD-24.



Even in Djakarta, Indonesia, the preference is for International power units. Here a UD-6 powers the government-owned Barber-Greene Model 879-A Finisher.

...WHY specify International® Power Units for bituminous plants?

These owners of Barber-Greene bituminous plants and pavers would give you these hard dollar reasons: Internationals have more features that pay off in lower production costs—and unsurpassed parts and service support for your convenience.

Economical? You bet, with a clean-burning exclusive injection and combustion system...a 45° angle of injection...new open-face single-orifice nozzles that give thousands of hours of coke-free operation.

Weather-proof? Definitely, with seconds-fast all-weather gasoline-conversion starting...full-flow filtering of all fuel, lube oil and air.

Dependable? Sure thing, with such features as tocco hardened crankshaft journals, precision insert bearings and replaceable hardened sleeves.

Heavy-duty? That's the only type of engine International has built in 55 years. And the positive-type valve rotators that make valve grinding such an infrequent need is just one of the famous IH long life features that have helped sell more than 400,000 diesels.

For more information, just see your easy-to-locate International Power Unit Distributor or Dealer. He'll provide proof you can specify and get an adaptable International power unit that's exactly right for your new or used machine. So be sure of profitable power for a long time to come by specifying Internationals for all of your driven machines.

INTERNATIONAL® CONSTRUCTION EQUIPMENT

International Harvester Co., 180 N. Michigan Avenue, Chicago 1, Illinois

A COMPLETE POWER PACKAGE INCLUDING: Crawler, Wheel, and Side-Boom Tractors... Self-Propelled Scrapers and Bottom-Dumps... Crawler and Rubber-Tired Loaders... Off-Highway Trucks... Diesel and Carbureted Engines... Motor Trucks.

ADVANCED!

. . . SINTERED POWDERED METAL BEARINGS and PARTS by Bunting!®

The newest facilities for the production of bearings and parts made of Sintered Powdered Metal and Cast Bronze Alloys are offered to designer, engineer and machinery manufacturer by The Bunting Brass and Bronze Company.

Bunting resources, reputation and responsibility together with a complete new plant and modern equipment provide Sintered Powdered Metal products at a high point of quality and precision.

Bunting Engineering is available without cost or obligation to all. Write for new Bunting Engineering Hand Book. 24 pages packed with new technical data on powdered metal products manufacture and application.

Sintered Plain and Flange Bearings, Solid and Tubular Bars and Thrust Bearings, Cast Bronze Plain Bearings and Bars are available from stock in a wide range of sizes. Quotations for special bearings or special parts will be sent promptly on receipt of prints.

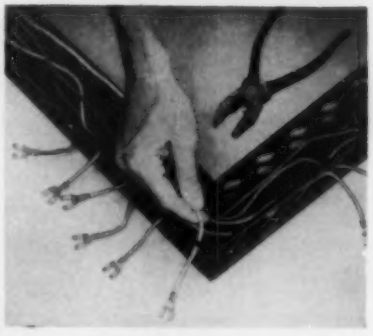
Bunting®

BUSHINGS, BEARINGS, BARS AND SPECIAL PARTS OF CAST BRONZE AND POWDERED METAL

The Bunting Brass and Bronze Company • Toledo 1, Ohio • Branches in Principal Cities

same channel. Square D Co., 4041 N. Richards St., Milwaukee 12, Wis.

For more information—
Circle 88, inside back cover



Panel Raceways

These raceways are said to eliminate wire bundling and lacing, reduce work and copper loss. The design provides slots, instead of holes. Wires with terminals can readily be passed through the slots. Arrangement of the wire slots permits wiring to leave the channel on the same plane as the destination terminal.

A phenolic compound is used for the channels that is not affected by normal high temperatures encountered in control panels. Sizes from 1 x 1 in. to 4 x 4 in. available from stock. Stahlin Brothers, Inc., 487 Maple St., Belding, Mich.

For more information—
Circle 89, inside back cover

Molded Variable Resistors

A 5-w molded composition variable resistor suited to industrial electronic applications has a solid-molded resistance element. The control has a maximum d-c working voltage of 750 v,

(Continued on page 310)

Small Motor... BIG Idea

FOR YOUR MOTOR-DRIVEN PRODUCT

This motor is representative of the many Lamb Electric motors *specially engineered* to provide:

(1) the dependable power and smooth, efficient operation required for top product *performance.*

(2) the low weight and compactness required for easy portability and good product *appearance.*

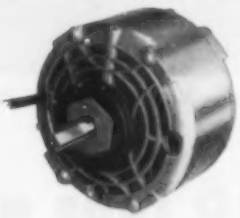
These advantages are standard with Lamb Electric Motors, at no increase in cost, because our plant is equipped and organized to *custom manufacture on a volume basis.* May we demonstrate?

THE LAMB ELECTRIC COMPANY • KENT, OHIO

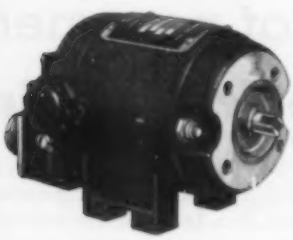
In Canada: Lamb Electric—Division of Sangamo Company Ltd.—Leaside, Ontario

Army tank ventilating blower motor.

Motor parts for portable electric tools.



Motor for air conditioning applications.



Motor for de-icer metering pump.

If you are interested in any of the above motors write and we shall be glad to send full information.

Lamb Electric

SPECIAL APPLICATION FRACTIONAL HORSEPOWER **MOTORS**

Blaw-Knox Bituminous Paver Finisher

200 tons an hour

is laying a lot of pavement and

Jeffrey chain helps!

That's 48 lineal feet per minute ... the pace maintained by this Blaw-Knox paver finisher on an airbase in Florida. Two Jeffrey chain conveyors carry the asphalt from the 10-ton hopper to the gates and screed, which assure smooth spreading even at this high speed.

You'll find Jeffrey chain on many manufacturers' products. It powers main and auxiliary drives, or serves on conveyors feeding materials into and out of their machines. Jeffrey chain is put there because these companies know they can depend on its accuracy and high quality. Good reasons for your asking for Jeffrey chain, too!

Whatever your power transmission or conveying problem, it will pay you to ask the nearby Jeffrey distributor for his recommendations. Or write The Jeffrey Manufacturing Company, Columbus 16, Ohio.

One of the two Jeffrey chain conveyors which keeps asphalt moving through this machine.

JEFFREY

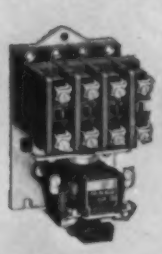
CONVEYING • PROCESSING • MINING EQUIPMENT
TRANSMISSION MACHINERY • CONTRACT MANUFACTURING

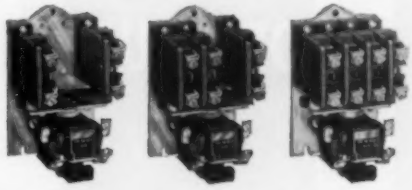
From 5 basic models you get 10 standard relays with the new CLARK Type "PM" Relay line

The 5 Basic Models

SECTIONAL POLE CONSTRUCTION—a new design concept for relays—provides units with 2 to 12 poles, with the greatest variety of combinations and pole arrangements available in an integrated 10-ampere line, and with a minimum of different parts to stock. Extra poles are available in kit form—assembled either normally open or closed. Coils and complete magnet assemblies are also available in kit form. Stocking of coils is simplified since one coil for a given voltage will handle any combination of 2, 3 or 4 poles normally open or closed, and for larger relays is correspondingly simple.

No. 5U-4
Basic
4-Pole

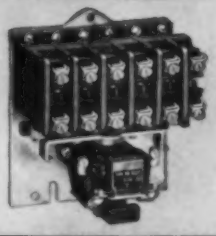


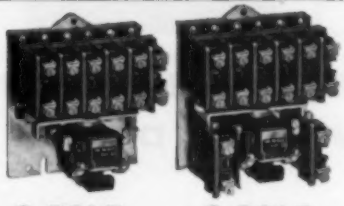


2-POLE 3-POLE 4-POLE

By removing one or two poles, the standard 4-pole unit becomes a 2 or 3-pole relay.

No. 5U-6
Basic
6-Pole

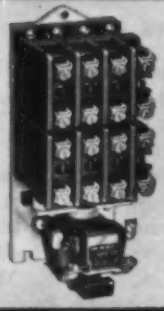


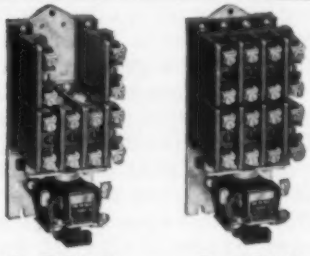


6-POLE 8-POLE

By adding 2 poles next to magnet, the standard 6-pole relay becomes an 8-pole unit—*the first 8-pole relay available for single deck wiring.*

No. 5UK-8
Basic
8-Pole

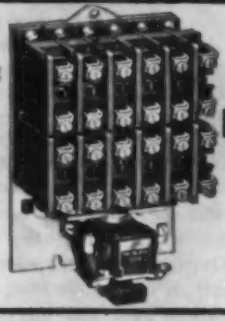


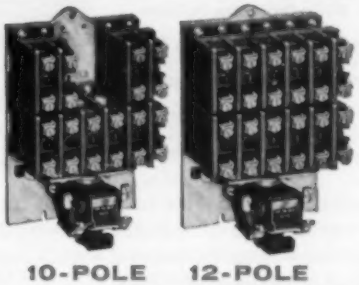


6-POLE Double-decked 8-POLE Double-decked

By removing 2 poles from the double-decked 8-pole relay, you get an alternate 6-pole of double-deck construction.

No. 5U-12
Basic
12-Pole

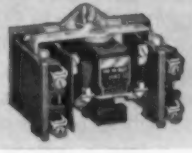




10-POLE 12-POLE

With 2 poles removed, the 12-pole unit becomes the standard 10-pole relay. Both have identical mounting dimensions with NEMA standard size 1 starters.

No. 5UK-2
2-Pole



2-POLE "SPACE SAVER"—a special purpose relay designed exclusively to meet small or unusual space requirements. Overall height less than 3 inches.

Write for 8-page illustrated Bulletin PL-7305 for complete information on this revolutionary new line of heavy-duty relays. Or contact your nearest Clark Distributor.

The CLARK CONTROLLER Company

Everything Under Control

1146 East 152nd Street • • Cleveland 10, Ohio

IN CANADA: CANADIAN CONTROLLERS, LIMITED • MAIN OFFICES AND PLANT, TORONTO

the BIG difference

BETWEEN

AVERAGE and OPTIMUM

MACHINE PRODUCTIVITY

...STERLING ELECTRIC POWER DRIVES

Machinery manufacturers and users in virtually every industry report outstanding performance achievements with Sterling Electric Power Drives ...achievements in greater productivity, in greater machine versatility, in lower maintenance cost, in rugged dependability...achievements that give dollars and cents proof that Sterling Electric Power Drives can make the *big* difference between average and optimum productivity of your machinery and equipment.

STERLING SPEED-TROL VARIABLE SPEED MOTORS

STERLING SLO-SPEED GEAR MOTORS

STERLING CONSTANT NORMAL SPEED MOTORS

STERLING MULTI-MOUNT SPEED REDUCERS

Write today for Bulletin No. 185. Discover the big advantages Sterling Electric Power Drives can bring to your plant.

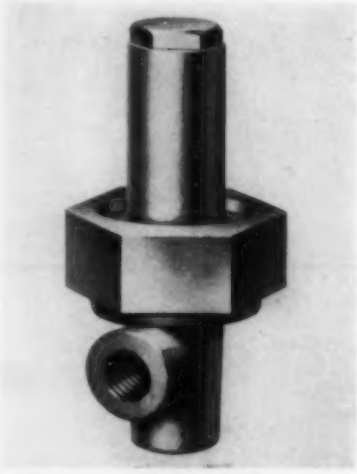
Sterling offers a wide range of Electric Power Drives of advanced design—variable or constant speed—with manual or automatic controls.

Sm STERLING ELECTRIC MOTORS

Los Angeles 22 • Chicago 35 • Cincinnati 37 • New York 51

a resistance range of 50 ohm to 2 megohm, and will operate effectively between temperatures of −55 c and 120 c. Allen-Bradley Co., 136 W. Greenfield Ave., Milwaukee 4, Wis.

For more information—
Circle 90, inside back cover



Relief and Back Pressure Valves

These relief and back pressure valves can be used at pressures to 1500 psi and temperatures to 250 F. These valves are protected by Kel-F thermoplastic diaphragms. Available in standard ¼, ½, ¾ and 1 in. sizes. Valve bodies are cast steel, 316 stainless steel, Carpenter 20 or Hastelloy C. Milton Roy Co., 1300 E. Mermaid Lane, Philadelphia 18, Pa.

For more information—
Circle 91, inside back cover

Cycle Timer

A timer for controlling on-off cycles of 10 sec to 12 min is recommended for use on ventilating fans, pumps, process timings, and other industrial uses requiring flexible operation. "On" operations may range from 10 sec to 11 min-10 sec. "Off" operations may be as short as 50 sec to 11 min-50 sec. Actually, the time dial will accommodate up to 12 sets of on-off trippers. This makes the unit infinitely adjustable through 90 percent of its 12 min range.

The unit measures 6½ x 5 x 3 in. deep. Presently, it is only available for

(Continued on page 314)

UNIVERSITY OF CALIFORNIA RADIATION LABORATORY

BERKELEY
LIVERMORE

Can you help add to these achievements?

The cyclotron

The synchrotron

The proton linear accelerator

The Bevatron

Electromagnetic separation of uranium-235

Discovery of plutonium and many other transuranium elements

Discovery of
URANIUM-233
TRITIUM
CARBON-14
IRON-59
IODINE-131

Discovery of the antiproton and antineutron

Artificial production of mesons

These accomplishments in pure and applied science are widely known. To this impressive list, scientists and engineers at the Laboratory's Livermore site are making equally important contributions in the fields of nuclear weapons design, nuclear rocket propulsion, controlled thermonuclear energy (Project Sherwood) and high current accelerators.

What you can do to help add to these accomplishments is limited only by yourself—your *ability* and your *interest.*

For the University of California Radiation Laboratory is managed and directed by outstanding scientists and engineers.

These men are your "team-mates"... offering pioneering knowledge of the nuclear field and the newest, most expansive laboratory facilities. Here—where new ideas and techniques are traditional—initiative is constantly encouraged and developed.

IF YOU are a **MECHANICAL** or **ELECTRONICS ENGINEER,** you may be involved in a project in any one of many interesting fields, as a basic member of the task force assigned each research problem. Your major contribution will be to design and test the necessary equipment, which calls for skill at improvising and the requisite imaginativeness to solve a broad scope of consistently unfamiliar and novel problems.

If you are a **CHEMIST** or **CHEMICAL ENGINEER,** you will work on investigations in radiochemistry, physical and inorganic chemistry and analytical chemistry. The chemical engineer is particularly concerned with the problems of nuclear rocket propulsion, weapons and reactors.

If you are a **PHYSICIST** or **MATHEMATICIAN** you may be involved in such fields of theoretical and experimental physics as weapons design, nuclear rockets, nuclear emulsions, scientific photography (including work in the new field of shock hydrodynamics), reaction history, critical assembly, nuclear physics, high current linear accelerator research, and the controlled release of thermonuclear energy.

In addition, you will be encouraged to explore fundamental problems of your own choosing and to publish your findings in the open literature.

And for your family—there's pleasant living to be had in Northern California's sunny, smog-free Livermore Valley, near excellent shopping centers, schools and the many cultural attractions of the San Francisco Bay Area.

You can help develop tomorrow—at UCRL today

Send for complete information on the facilities, work, personnel plans and benefits and the good living your family can enjoy.

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DIRECTOR OF PROFESSIONAL PERSONNEL
UNIVERSITY OF CALIFORNIA RADIATION LABORATORY
LIVERMORE, CALIFORNIA

Please send me complete information describing UCRL facilities, projects and opportunities.

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*My degree(s) are*_____

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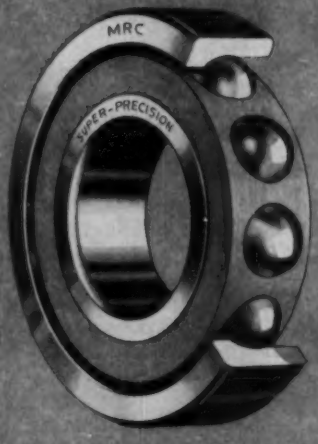
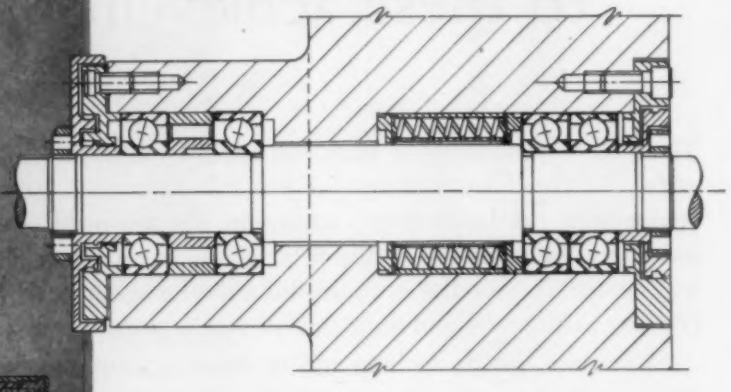
*City*_____ *Zone*____ *State*_____

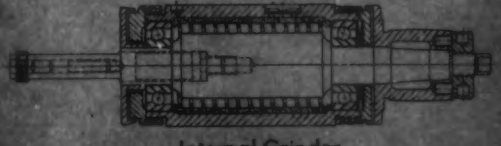
Long life accuracy

IN MACHINE TOOL SPINDLES with M-R-C SUPER-PRECISION BALL BEARINGS

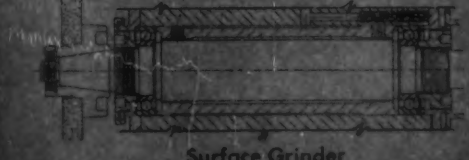




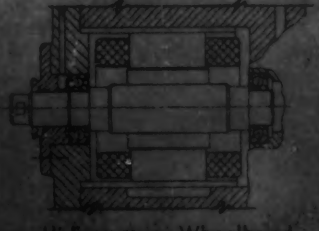
Grinder Spindle



Internal Grinder



Surface Grinder



Hi-Frequency Wheelhead

M-R-C Ball Bearings are used today in many leading machine tool spindles operating successfully at 100,000 RPM and over.

The illustration above is an example of a successful application of M-R-C SUPER-PRECISION bearings. This grinder spindle requires the highest degree of accuracy and long life obtainable only with M-R-C SUPER-PRECISION.

Still higher standards have been made possible by the facilities of our new SUPER-PRECISION plant devoted exclusively to this type bearing.

There is a M-R-C Ball Bearing for every machine tool application requiring accuracy and long life.

Consult OUR Engineering Department on YOUR bearing problems

MRC
BALL AND ROLLER *bearings*

MARLIN-ROCKWELL CORPORATION

Executive Offices: **Jamestown, N.Y.**

....for better FORGING PRODUCTION!

Sharon Open Hearth Quality Forging Ingots — now available in Carbon and Alloy grades, with ingot weights up to 109,000 pounds. Sharon Electric Furnace Quality Ingots — Stainless and Alloy grades, up to 50,000 pounds. • Sharon is also a prime supplier of billets, blooms and slabs — to customer specifications — in Stainless and Alloy grades. For prices — contact the Sharon Steel Corporation, Forging and Semi-Finished Steel Sales Department — or one of the district sales offices listed below.

SHARONSTEEL

SHARON STEEL CORPORATION *Sharon, Pennsylvania*

DISTRICT SALES OFFICES: Chicago, Cincinnati, Cleveland, Dayton, Detroit, Grand Rapids, Indianapolis, Los Angeles, Milwaukee, New York, Philadelphia, Rochester, San Francisco, Sharon, Seattle, Montreal, Que., Toronto, Ont.

"BRAIN-SHRINKING"
FOR ELECTRONIC SYSTEMS
made possible by Elgin's new
NEOMITE RELAY

How can you shrink the size and weight of the complex electronic "brains" so necessary in modern industrial and defense equipment? Elgin provides the answer with new watch-precision NEOMITE Relays . . . the world's smallest, requiring only 100 milliwatts to open and close electrical circuits.

Write today for complete information.

Specifications

Contacts; Arrangement: 1 Form "C" (SPDT) Rating: 28 v DC, at 250 ma. Resistive Load.

Contact Resistance. .03 ohms maximum, .05 ohms after 1,000,000 operations at Specified Load.

Coil Operating Specifications. Pull-In: 7 MA or less. Drop-Out: 30 to 60% of Pull-In. Coil Resistance: 2000 Ohms ± 10% at 20° C. Operating Voltage: 18 to 30 v DC.

Vibration Resistance. 10 G, up to 500 cps.

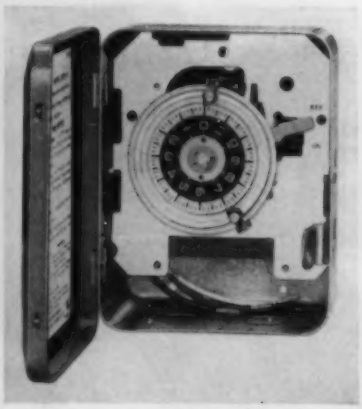
Shock. 50 G, without damage.

Temperature Range. —55° C. to +85° C.

ACTUAL SIZE
.09 ounces . . . just 0.392" x 0.195" x 0.530" high.
AVAILABLE COIL RESISTANCES —50, 200, 500, 1000, 2000 Ohms.

ELECTRONICS DIVISION
ELGIN NATIONAL WATCH COMPANY
Elgin, Illinois

Sales representatives in principal cities.



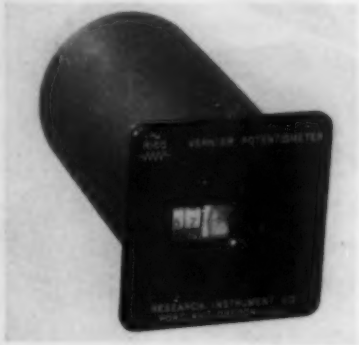
125 v operation, with a capacity of 1875 w. International Register Co., 2624 W. Washington Blvd., Chicago 12, Ill.

For more information—
Circle 92, inside back cover

Stainless Steel Clamp

Temperatures as high as 1500 F are withstood by this stainless steel cushion clamp. The cushion is corrugated to furnish a spring action for high frequency, low amplitude vibration. The clamp is available in sizes from ¼ to 3 in. ID. TA Mfg. Corp., 4607 Alger St., Los Angeles 39, Calif.

For more information—
Circle 93, inside back cover



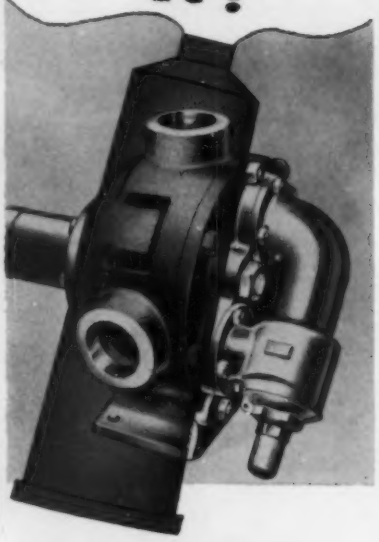
Vernier Potentiometer

A single knob operates either of two resistance decades or the interpolating potentiometer. Simply push or pull the knob and read out the number as the knob is turned. Parallax is eliminated. Three turns of the knob cover the full range.

The unit mounts similar to a square-

(Continued on page 317)

HOW DO YOU HANDLE IT?



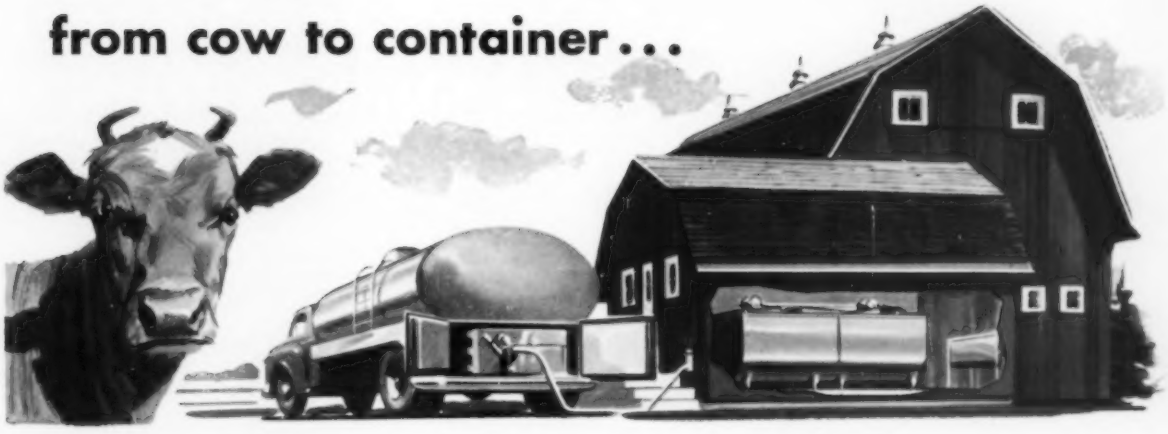
PUMP IT WITH A VIKING

Here's the answer to your problem of moving semi-solid materials of types usually dispensed in squeeze tubes. With Vikings you can pump such materials as tooth paste, shaving cream, petroleum jelly and many others, in a smooth, even flow. Hundreds of plants are doing it.

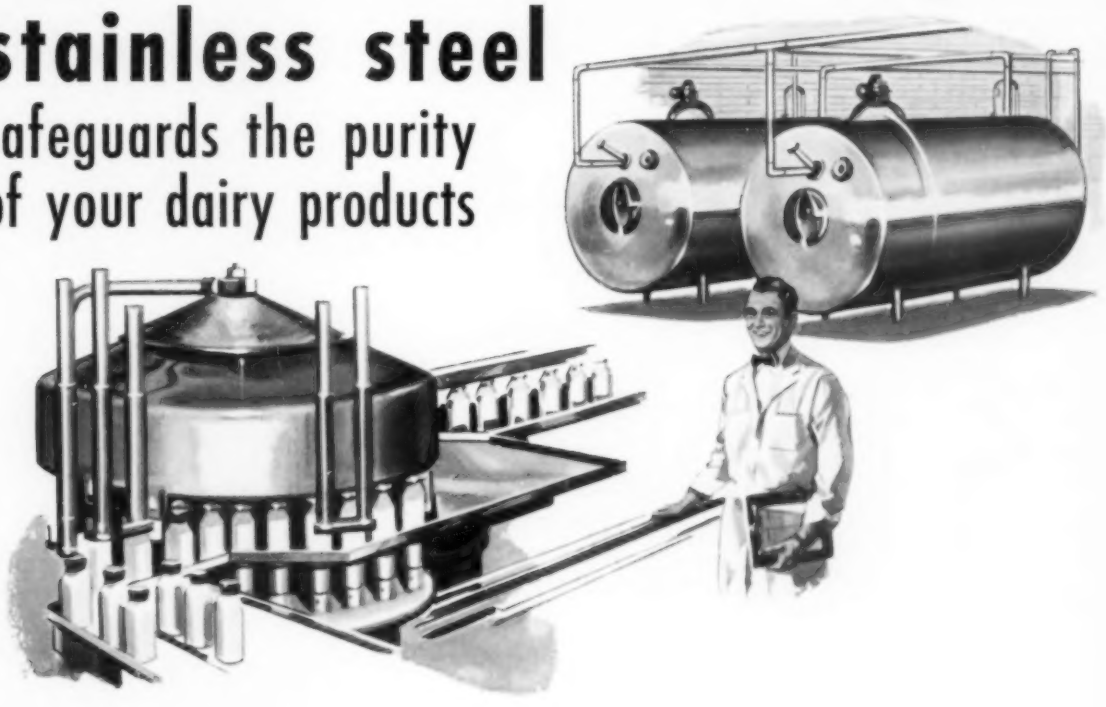
Viking's simple, rugged "gear within a gear" principle makes it adaptable to most pumping needs. There are 750 catalogued models and thousands of specially built pumps and units. If you have a pumping problem, call on Viking Pumps for assistance. Ask for bulletin 57Sx.

VIKING PUMP CO.
Cedar Falls, Iowa, U.S.A.
In Canada, it's "ROTO-KING" pumps
SEE OUR CATALOG IN SWEETS

from cow to container...



stainless steel
safeguards the purity of your dairy products



Dairymen and milk-product plant operators know that Stainless Steel is the only metal that year after year effectively resists acid corrosion. It can easily be kept clean and sterile and imparts no odor in contact with the product.

Through all the stages of milking, transportation, processing and packaging Stainless Steel completely safeguards the delicate flavor and highly sensitive qualities of milk and cream, and milk products like butter, cheese, ice cream and powdered milk.

The delicious taste of your dairy products and the assurance of their purity is due to the dairyman's extreme care and scientific methods and the use of Stainless Steel equipment.

McLOUTH STAINLESS STEEL

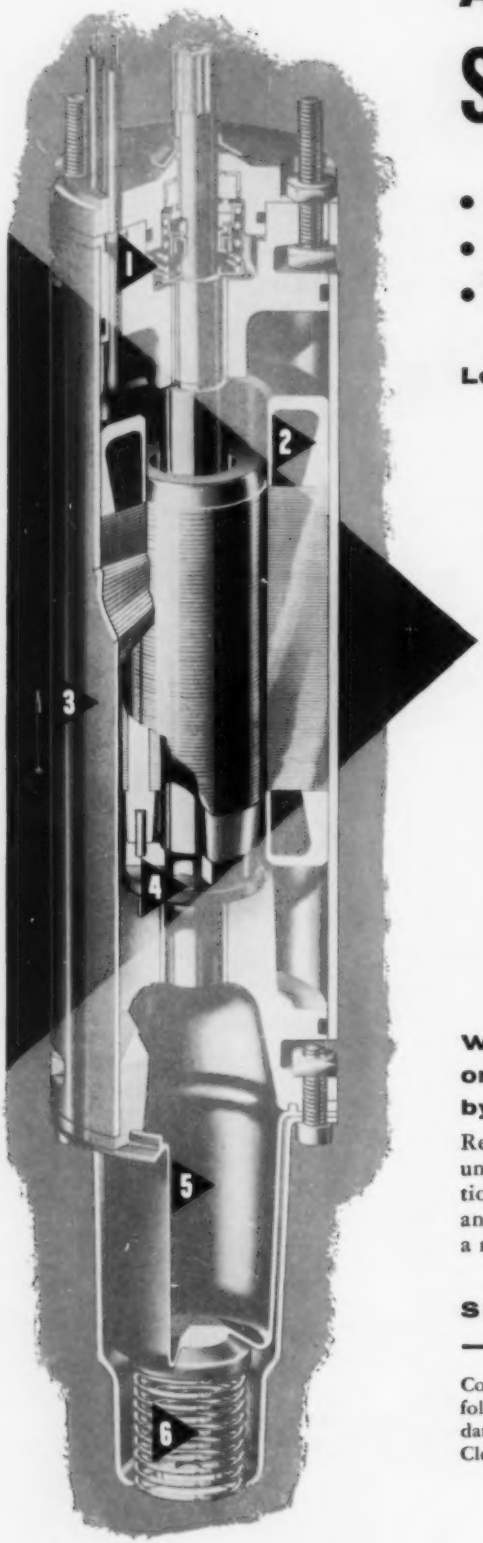
For the product you make today and the product you plan for tomorrow specify McLouth high quality sheet and strip Stainless Steel

McLOUTH STEEL CORPORATION DETROIT, MICHIGAN • MANUFACTURERS OF STAINLESS AND CARBON STEELS

Announcing a *CUSTOMIZED*

SUBMERSIBLE MOTOR

- **that fits in a small-diameter casing**
- **that gives you high output**
- **that runs in water, oil or other fluids**



Look at typical features of a J&H Underwater Motor

1 *Rotary Seal*—Ceramic and graphitar faces, carefully lapped to insure against entry of water and contaminants.

2 *Encapsulated Windings*—A special J&H epoxy compound is used for "potting." Epoxy has exceptional heat conductivity and does not buckle or swell under many abnormal conditions. "Potting" prevents winding failure, even if water enters motor. In fact, motor will operate as water-filled unit.

3 *Corrosion-resistant Epoxy Paint Finish.*

4 *Segmented Tilting-shoe Self-aligning Thrust Assembly*—Ample reserve thrust carrying capacity is provided. Faces accurately lapped for long wear.

5 *Oil-filled Motor*—A large reservoir of oil provides additional dielectric strength, insures longer seal and bearing life, protection against corrosion.

6 *Controlled Pressure System*—Diaphragm and spring assembly insures an internal pressure sufficient to prevent infiltration by external contaminants, which could occur with normal seal wear.

● *L/D Ratio To Suit*—Length/diameter ratio can be varied to fit casing, tank, pipeline or other designated location.

Whether you're pumping water, crude oil, gasoline or other fluids, your motor need can be met quickly by Jack & Heintz!

Retaining the size flexibility and long service life features of the underwater motors, J&H designers have already developed modifications for operation in crude oil, gasoline and other fluids. Customizing any of the proved basic designs to meet your specific needs is only a matter of defining your service and dimensional requirements.

SEND FOR DATA TODAY

Confer with J&H motor specialists or write for folder which gives rating and performance data: Jack & Heintz, Inc., 17627 Broadway, Cleveland 1, Ohio.

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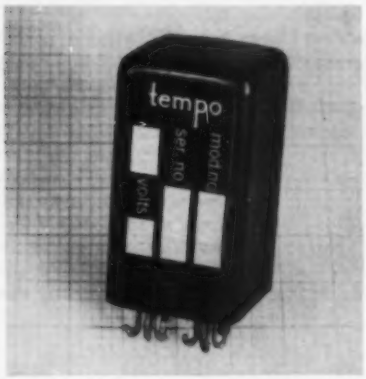
JACK & HEINTZ ***CUSTOMIZED*** ELECTRIC MOTORS

cased panel meter and matches the regular 3-in. meter in size and shape, except for depth behind the panel. This voltage divider has an input resistance of 10,000 ohm, ± 0.01 per cent, resolution of 0.002 per cent and is rated at 5 w. Research Instrument Co., P. O. Box 9168, Portland 16, Ore.

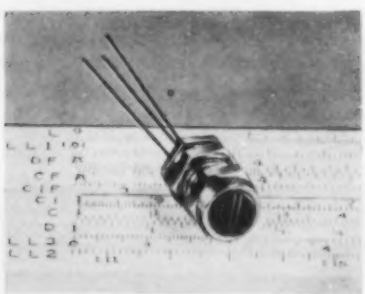
For more information—
Circle 94, inside back cover



Miniature Time Delay Relay

Models are available with relay periods from 0.1 to 5 sec. Size is 1 x 1 x 1½ in. Weight is less than 2 oz. Both d-c and a-c models are offered; d-c inputs from 28 v to 150 v., a-c from 26 to 115 v at 60 cps to 400 cps. Tempo Instrument Co., 5 Centre St., Hempstead, N. Y.

For more information—
Circle 95, inside back cover



Potentiometer in Locking Bushing

This unit is essentially a locking bushing with a potentiometer built inside. Rather than affixing a locking device to a potentiometer housing for the purpose of locking the potentiometer shaft, this unit has been de-

(Continued on page 320)

It's designed and built the way you would do it for

efficient liquid flow!

Glance at this exploded view of the

INGERSOLL-RAND

MOTORPUMP

Now you have an idea of the clean-cut simplicity of its efficient design. It's the design that gives continuous full-load capacity—the reason I-R Motorpumps have been out in front over the years.

They're compact—valuable space is saved. Durable—low maintenance is assured. And because you can specify Motorpumps which operate in *any* position your design problems are greatly simplified.

Moreover, the Motorpump line is so complete that you can specify anywhere from ¼ hp to a powerful 75 hp size . . . 5 to 2800 gpm . . . by standardizing on I-R!

If you are not familiar with the full line of centrifugal, circulating and coolant Motorpumps, we'll be glad to send you our latest catalogs. Write today.

Ingersoll-Rand

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Copyflex Machines and Sensitized Materials

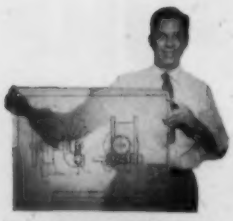
ADD MANPOWER TO YOUR DRAFTING ROOM

Modern Reproduction Machines, Materials, and Techniques Cut

The boom in production means more pressure than ever for engineering prints and drawings. Now, more than ever, is the time to (1) replace that old, inadequate reproduction unit with a modern, efficient Copyflex machine and (2) capitalize on the many drafting shortcuts made possible by Copyflex reproduction machines and sensitized materials.

Six New, Advanced Machines: In just the past 18 months Bruning has introduced six new, greatly improved models—five of which are shown at right. They bring you not only faster reproduction but a host of design improvements that will boost your drafting room output sharply. One of these six new machines will surely meet your exact requirements.

Slash Re-Drafting Time: Your Copyflex machine is more than a means of making conventional opaque prints of finished drawings—it can also help you in your actual drafting operations. In many cases involving the re-working of existing drawings, for instance, it can save you up to 90% in tracing time through the use of translucent prints ("intermediates") made on film, cloth, or low-cost paper. Consider how much of your drafting is devoted to design changes, changes in standards, and similar alterations and you'll see why adding Copyflex to your production team will *add manpower to your drafting room.*



This design change took hours to make because it was done entirely at the drawing board.

The same design change was completed in less than an hour with the aid of a Copyflex intermediate.

These Materials Speed Reproduction *and* Drafting

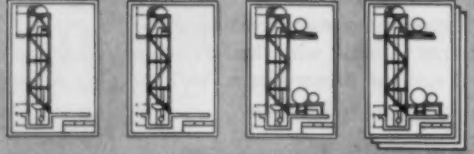
Copyflex Translucent Sensitized Paper: Prints made on this 100% rag, resin-transparentized medium provide: (1) a positive, reproducible image of all or any selected part of an original; (2) a workable drawing surface for making additions or alterations; and (3) excellent translucency for making fast, sharp reproductions. In the making of design changes, prints made on this paper eliminate the need for tracing those sections of the design which do not require alteration. Unwanted portions can either be masked out in the printing operation or eradicated on the translucent print . . . then new lines added. The paper prints accept pencil and ink, and drawn lines are erasable. Subsequent alterations are achieved just as easily and quickly by use of the same reproduction-drafting technique.

Copyflex Sensitized Matte Film: Usable for same purposes as Copyflex Translucent Sensitized Paper, but is highly transparent and much more durable. Reproduces faster than originals made on tracing paper.

Copyflex Sensitized Clear Film: Offers complete transparency and extremely fast reproduction speed. Not suitable for drawing, but ideal for making composite prints, overlays, and projection prints. Various developers can be applied to it to produce different color effects.

Copyflex Sensitized Tracing Cloth: A top quality moisture repellent cloth with excellent pencil and ink workability. The ideal material to use when circumstances require a translucent print with exceptional durability and strength.

HOW COPYFLEX SPEEDS DESIGN CHANGES



Original Drawing | Translucent Print of Original | Print with Alterations Drawn In | Prints Made from Altered Intermediate

Problem: To make a design change without marking or altering the original drawing or tracing.

Old Method: (1) Trace unchanged parts of the original by hand; (2) draw in the design changes or alterations.

Copyflex Method: (1) Reproduce unchanged parts of the original in a matter of seconds on Copyflex translucent paper, cloth, or film—blocking out or later eradicating any unwanted portions of the original design; (2) draw in the design changes or alterations.

Result: Substantial savings in time, money, and drafting room manpower.

NEW!

Desktop Model 300: Perfect for small firms, an ideal "extra" machine for large firms. Makes prints up to 30" wide by any length. Operates on 110 volt A.C.

Drafting Time, Boost Productivity!

NEW!

Model 500: A heavy-volume machine offering top mechanical speed of 40 f.p.m., 46" printing width, automatic separation and stacking, front or rear delivery, and many other advanced features.

Model 250: Takes less than a sq. yd. of floor space. Has top mechanical speed of 25 f.p.m., 18½" printing width, automatic separation and stacking. Operates on 220 volt A.C.

Model 200: A 110 volt A.C. version of the Model 250.

NEW!

NEW!

Model 35: Provides up to 30 f.p.m. mechanical speed and a full 46" print-width for heavy volume reproduction at a thrifty, low cost.

Model 20: Not a new model, but a dependable performer well worth your consideration. Makes prints up to 46" wide. Operates on 110 volt A.C.

Model 30: A faster, 220-volt version of the Model 20.

Desktop Model 110: A new and improved small machine with 11" printing width. Makes 8½"x11" prints for less than 1¢ each for materials. The helper your big machine needs!

NEW!

SEND FOR MORE INFORMATION TODAY!

BRUNING Copyflex

Best Process! Best Machines! Best Selection of Materials!

Offices in 37 Cities of the U.S. and Canada

CHARLES BRUNING COMPANY, INC., 4700 Montrose Ave., Chicago 41, Ill.
In Canada: Charles Bruning Co. (Canada) Ltd., 105 Church St., Toronto 1, Ont.

Charles Bruning Company, Inc., Dept 13-O
4700 Montrose Ave., Chicago 41, Illinois

Please send me information on the Copyflex process and the following machine(s):_____
and sensitized materials:_____

Name_____ **Title**_____

Company_____

Address_____

City_____ **County**_____ **State**_____

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Physical Testing Laboratory

Injection Molding

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Today, this company offers engineering and manufacturing talent and facilities unmatched in the industry to assist its customers in the profitable application of these and other plastics for almost countless purposes.

This company also is the only manufacturer offering the user of these materials a complete line of molded and extruded stock from which he may produce his own parts—*plus* modern, high-speed, low-cost machining facilities for producing his parts for him to close tolerances—*plus* an extensive injection molding plant for the maximum economy in large volume production.

Hence, we not only provide for the manufacturer's needs at the prototype and limited production stages of his product—but supply the answer to the most efficient method, and an accurate yardstick of cost-measurement, in the production of his ultimate requirements.

Send us your drawings or samples for estimates, or write for 20-page brochure "Inside U.S.G.".

*du Pont's trademark for its tetrafluorothylene resin.
†Kellogg's trademark for its trifluorochloroethylene resin.

UNITED STATES GASKET CO.

CAMDEN 1, NEW JERSEY

signed so that the potentiometer is completely housed by the locking device itself. The bushing is stainless steel, mounts in a ⅜ in. hole, and is approximately ⅝ in. long. The device is available in 16 standard resistance values from 47 to 15,000 ohm. Carter Mfg. Corp., 23 Washington St., Hudson, Mass.

For more information—
Circle 96, inside back cover

Subminiature Feed-Through Terminal

Standard basic dimensions are 0.770 x 0.047 x ⅛ in. hex nut dia. Standard body material is melamine, electrical grade. Terminal is silver plated, the nut nickle plated. Whitso, Inc., Dept. PEN, 9330 Byron St., Schiller Park, Ill.

For more information—
Circle 97, inside back cover

Ultrasonic Soldering Iron

This soldering iron, capable of soldering aluminum without flux by completely removing the oxide film on the metal surface, applies ultrasonic power through the molten solder to the surface of the aluminum or other

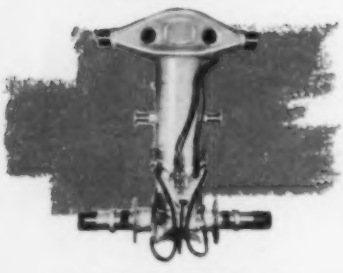
(Continued on page 324)

Jet engine spacer ring

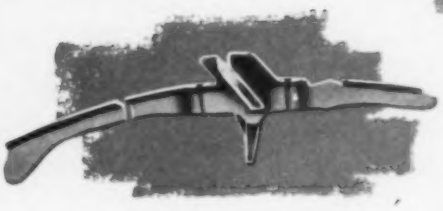
Save up to 70%
on material costs
CUT machining costs by 50%

Bulkhead

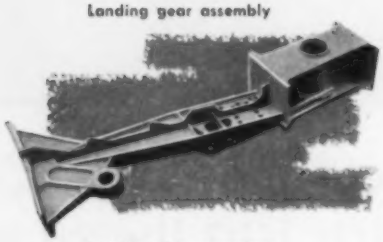
Bomber nose



Landing gear assembly



Inboard strut for airframe assembly



Stabilizer hinge support

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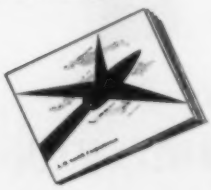
Engineered Designs for Optimum Structures

Put your complex components in the hands of A. O. Smith! Exclusive E.D.O.S. manufacturing process is faster than conventional methods . . . assures a stronger product . . . cuts your costs.

For example, a conventional titanium rough-forged jet engine ring, 17½" O.D. x 5½" wide, weighs 70 pounds — while its counterpart, an E.D.O.S. precision-forged, contour-rolled titanium ring, weighs but 20 pounds! Save 71% on material . . . 50% on machining time.

This remarkable metal- and work-saving process is ideal for titanium, steel and other heat-resistant alloys . . . may be the answer for fabricating your product. For further details about E.D.O.S., contact A. O. Smith Corporation, Milwaukee 1, Wisconsin.



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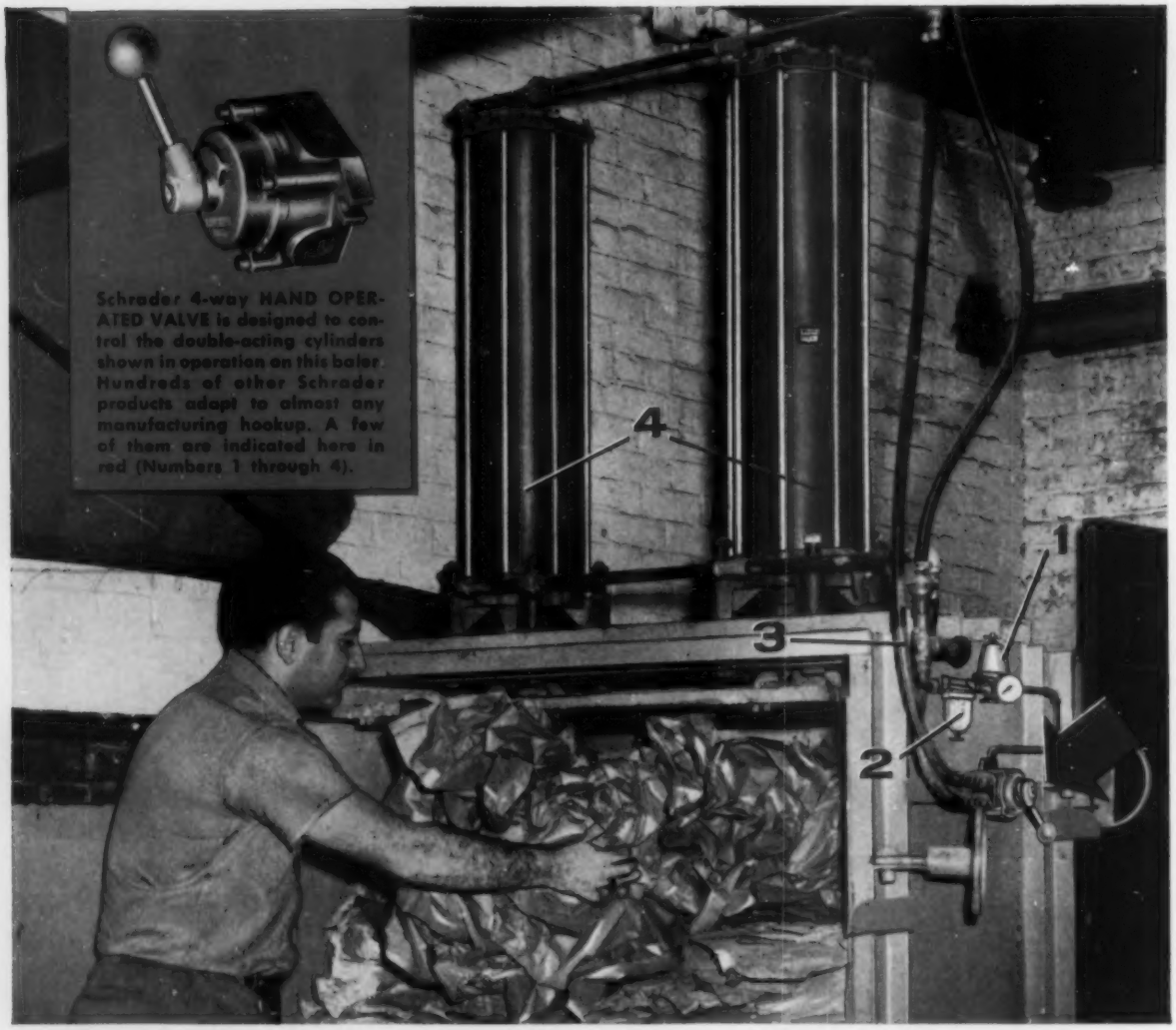
Schrader 4-way HAND OPERATED VALVE is designed to control the double-acting cylinders shown in operation on this baler. Hundreds of other Schrader products adapt to almost any manufacturing hookup. A few of them are indicated here in red (Numbers 1 through 4).
4
1
3
2

How Schrader Air Products bale paper, producing 4 ton pressure with 100 lbs. of air

At this Rhode Island dye works, the paper baling operation formerly was a fatiguing manual chore. Now, the operator simply fills the press with used paper and cartons, and pulls a 4-way hand valve. One hundred pounds of air pressure flowing through the two Schrader double-acting cylinders then compress the paper with four tons of force. Finger-tip adjustments can reduce or raise pressure quickly, easily.

Safe, simple, fast—compressed air daily performs miracles in hundreds of different ways. More and more manufacturers think "air" when they think "automation." Holding work, moving scraps, synchronizing actions—all such operations can be automated with Schrader Air Products.

Air means economy, too. Upon request, Schrader engineers will assist you in planning for the most efficient use of air and in selecting the products best suited to your applications. Tell us your problems. We'll be glad to help. Or send for the latest informative booklets.

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OPPORTUNITIES IN DESIGN, development, production-engineering and packaging of mechanical, electronic and electro-mechanical devices.

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YOUR WORK AT NCR with its friendly, family atmosphere, where you work with people who, like yourself, have decided to build their professional future with NCR.

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E. B. WIGGINS OIL TOOL COMPANY, INC.
3424 E. Olympic Blvd, Los Angeles 23, Calif

If it's got to connect . . . connect with WIGGINS

light metal. A "cold boiling" effect, called cavitation, is produced within the solder. The cavitation bubbles remove oxide film from the metal surface, allowing a wetting action by the solder. The soldering iron has a pistol grip and can be supplied with a choice of either a chisel-shaped or tapered copper bit. Power is from a special power unit. Acoustica Associates Inc., Glenwood Landing, N. Y.

For more information—
Circle 98, inside back cover

Circuit Continuity Tester

This electrical circuit tester consists of an industrial flashlight with built-in jack. The test leads use plug and clips for instant attachment. This tester, which works through a 3-v battery supply has many uses, such as checking wiring, controls, circuits, fuses, grounds, shorts, opens, broken wire, switches, limits, relays, burglar alarm systems, also for checking and setting contacts as desired. Bright Star Industries, Clifton, N. J.

For more information—
Circle 99, inside back cover

Dynamometer for Testing Servo-Mounted Motors

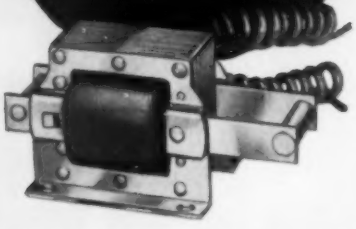
This dynamometer has a hysteresis brake to absorb motor power in the testing of servo-mounted miniature motors. The torque system balances the running torque of the test motor against the swing of a carefully calibrated pendulum weight. The rotor of the brake assembly is carried directly on the test motor.

The unit can be made in maximum torque scales down to 0.5 in-oz and up

(Continued on page 328)

DORMEYER SOLENOIDS

Engineered TO OUTLAST PRODUCT LIFE



MILLIONS OF CYCLES constitute standard DORMEYER dependability. DORMEYER solenoids serving this long *and longer* continue in smooth operation in countless products today.

All types and sizes available to meet your needs. DORMEYER quality means dependable, long-lasting, trouble-free circuit operation...and DORMEYER production facilities mean low unit cost, on-time delivery.

DORMEYER electro-mechanical controls can be custom-engineered to your requirements...depend on our 30 years of specialized experience to solve your problems.

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Weirkote shrugs off punishment like that—or far worse—in everyday production. Its continuous-process zinc coating goes through all the severe fabrication steps flawlessly. Spin it, deep-draw it, crimp it, roll-form or extrude it. There's no flaking or peeling when Weirkote's on the job.

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Send for all the facts on Weirkote. Write Weirton Steel Company, Dept. D-5, Weirton, West Virginia.

WEIRTON STEEL COMPANY

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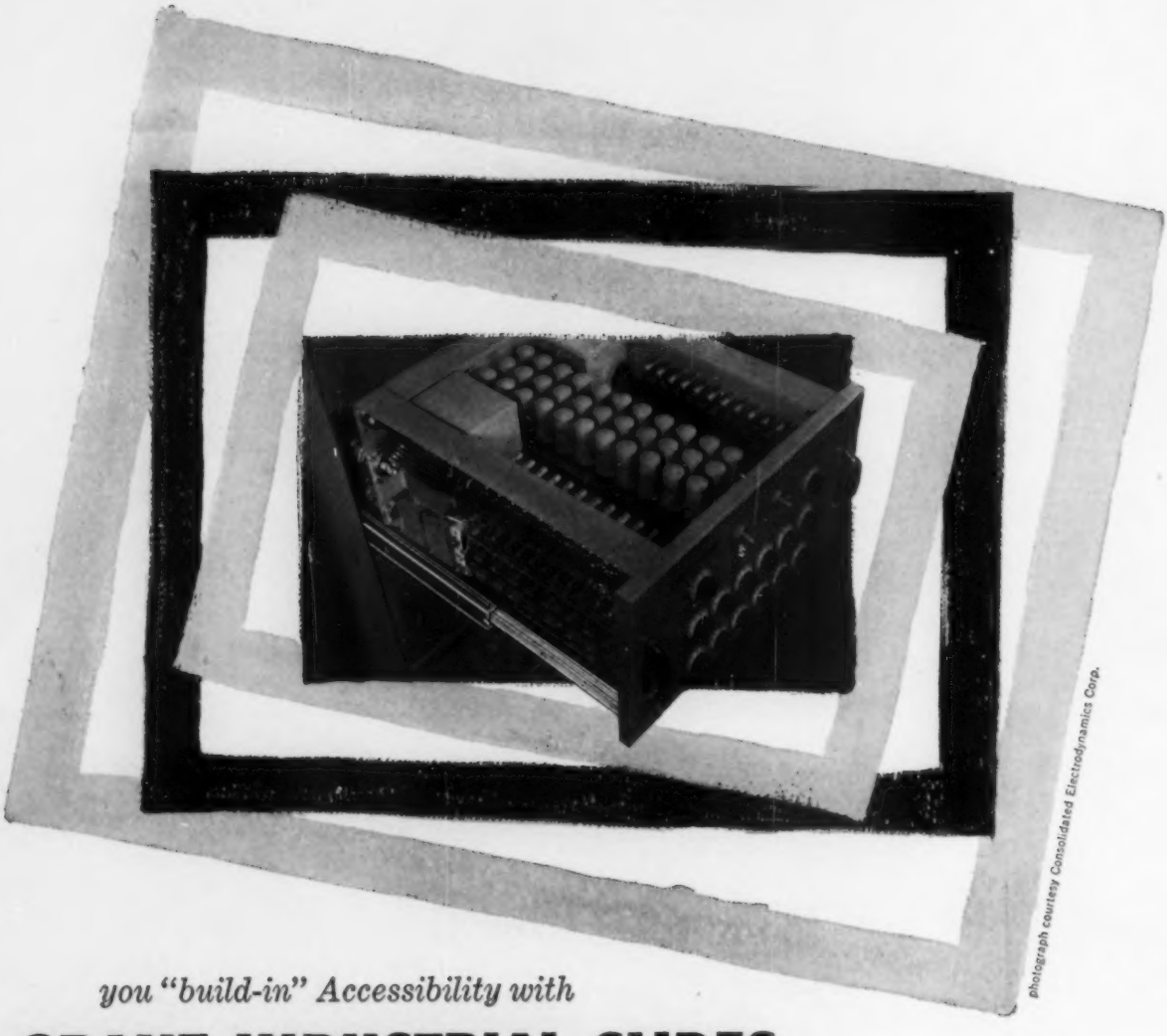

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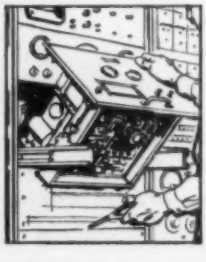

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5. **Excellent uniformity of weight and thickness.**
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7. **Good resin pickup (wettability) due to large amount of fiber surface available.**
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9. **High strength and elongation properties which may eliminate the need for pre-forming in deep draw applications, and prevent tearing in vari-shaped molded applications.**
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Investigate **FEUTRON** felts further, by sending for Technical Bulletin, making request on your firm's letterhead. *Registered trademark

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For more information—
Circle 100, inside back cover

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For more information—
Circle 101, inside back cover

Lettering Guide

This lettering template is made of 0.060 in. acrylic. It is cut in five guide slots, $\frac{1}{8}$, $\frac{5}{32}$, $\frac{1}{4}$, $\frac{3}{8}$ and $\frac{1}{2}$ in. Five circles in these same sizes have also been incorporated. In addition, the top of the template is a 6 in. ruler in 16ths and the bottom a 6 in. ruler in millimeters. Over-all size is $4\frac{1}{8}$ x $6\frac{3}{4}$ in. Alvin & Co., Windsor, Conn.

For more information—
Circle 102, inside back cover

Storage Oscilloscope

This unit captures and retains any number of traces indefinitely at a constant intensity until intentionally erased. The scope is available in a portable model 13 x 14 x 20 in. deep and another, rack-mounted, 14 x 19 in. Hughes Products, International Airport Station, Los Angeles 45, Calif.

For more information—
Circle 103, inside back cover

Circle Templates

Each template has 45 circles, from $\frac{1}{16}$ to $2\frac{1}{4}$ in. dia., increments 64ths to $\frac{1}{32}$ in., 32nds to $\frac{1}{8}$ in., 16ths to 1 in. and 8ths to $2\frac{1}{4}$ in. Made of 0.030 in. matte finish plastic. Actual size is $8\frac{1}{4}$ by $7\frac{1}{4}$ in. Rapidesign, Inc., Box 592, Glendale Calif.

For more information—
Circle 104, inside back cover

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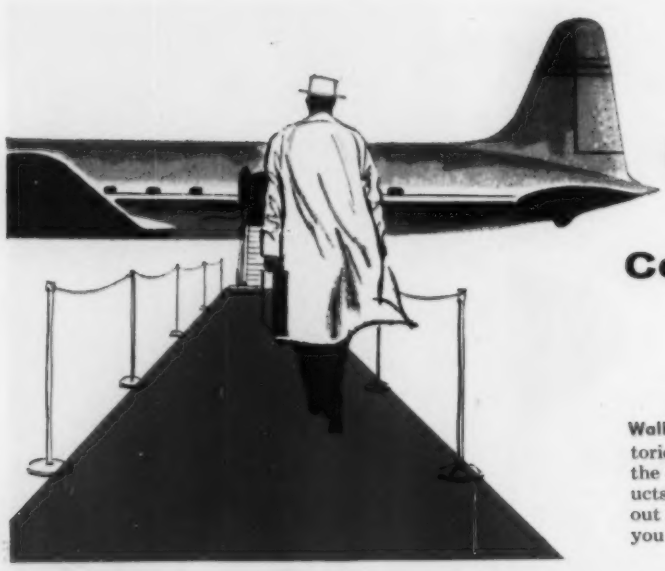

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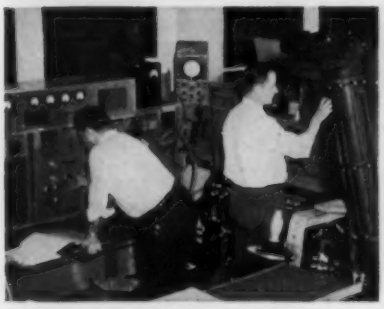

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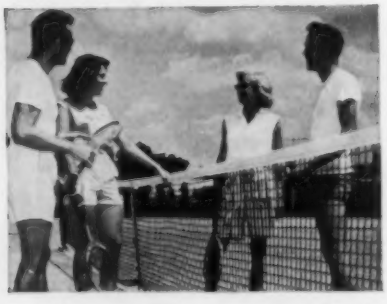

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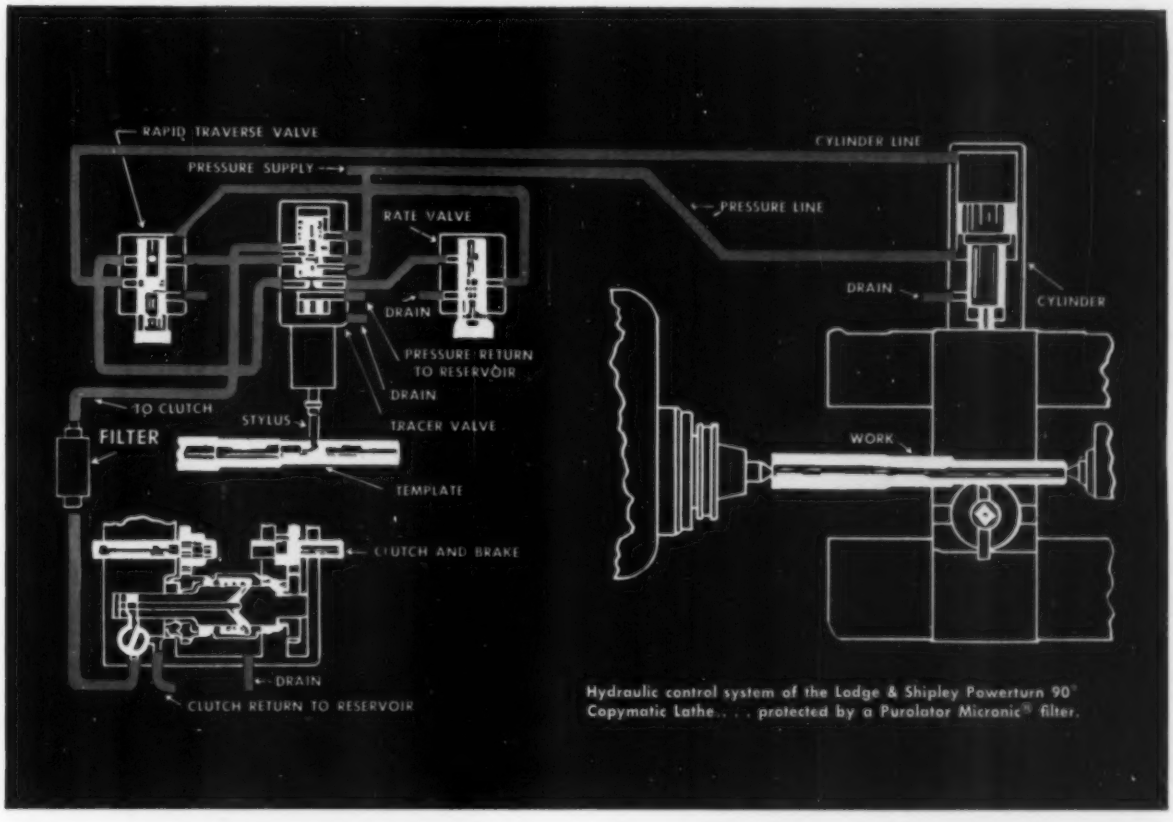

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CATALOGS and BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 348.

Stamped Gears–Catalog, 31 pp. Contains data and charts on precision gears up to 4 in. dia. Fastex, 195 Algonquin Rd., Des Plaines, Ill.

Circle 105, inside back cover

Fasteners–Catalog, 23 pp. Contains data and diagrams on spring units, studs, pins and grommets. Fastex, 195 Algonquin Rd., Des Plaines, Ill.

Circle 106, inside back cover

Spring Design and Selection–Brochure, 8 pp. Contains stress and deflection formulas, spring materials, applications, and limitations of various type springs. Associated Spring Corp., Bristol, Conn.

Circle 107, inside back cover

Variable Resistors and Switches–Bulletin RC1OB, 30 pp. Contains data and chart on dimensions, mounting styles, ratings, and standard modifications. Stackpole Carbon Co., St. Marys, Pa.

Circle 108, inside back cover

Silicon Rectifiers–Brochure ECE-148A, 11 pp. Contains application notes on the 4JA60 series of small high current units. General Electric Co., Electronics Park, Syracuse, N. Y.

Circle 109, inside back cover

Standards for Stud Welding–Booklet, 35 pp. Contains diagrams and data on studs, pins and tapped pads. K S M Products, Inc., Merchantville 8, N. J.

Circle 110, inside back cover

Synchros–Brochure, 12 pp. Contains diagrams and data on units, size 1, 3 and 5. Ford Instrument Co., 31-10 Thomson Ave., Long Island City 1, N. Y.

Circle 111, inside back cover

Fasteners–Brochure, 12 pp. Contains data and charts on washers, screws, nuts and terminals. Shakeproof, St. Charles Rd., Elgin, Ill.

Circle 112, inside back cover

Standards for Miniature Screw Threads–Bulletin, 17 pp. Contains a tentative draft from sectional committee B1 on the standardization and unification of screw threads. ASME, 29 W. 39 St., New York 18, N. Y.

Circle 113, inside back cover

Lubrication Fittings–Bulletin, 8 pp. Contains diagrams and data on ball-in-head, flush and button fittings. Universal Lubricating Systems, Inc., Oakmont, Pa.

Circle 114, inside back cover

Protective Coatings–Bulletin, 32 pp. Contains data on vinyl chloride resins for solution coatings. Firestone Plastics Co., P.O. Box 690, Pottstown, Pa.

Circle 115, inside back cover

Where Engineers Work in Industry–Booklet, 11 pp. Contains the results of two surveys by National Education Committee. American Society of Tool Engineers, 10700 Puritan Ave., Detroit, Mich.

Circle 116, inside back cover

Metal Laminates–Brochure, 8 pp. Contains data on laminates which are combinations of two or three metals permanently and metallurgically bonded together to form a "sandwich." Bridgeport Brass Co., Bridgeport 2, Conn.

Circle 117, inside back cover

Wire, Rod and Alloys–Booklet, 28 pp. Gives price schedule and data. Techalloy Co., Inc., Rahns, Pa.

Circle 118, inside back cover

High Pressure Gage Snubber–Brochure, 2 pp. Contains diagram and data. Chemiquip Co., 460 W. Broadway, New York 12, N. Y.

Circle 119, inside back cover

Phosphor-Bronze–Data Sheet, 4 pp. Contains information on the physical characteristics, processing, and appli-

(Continued on page 336)

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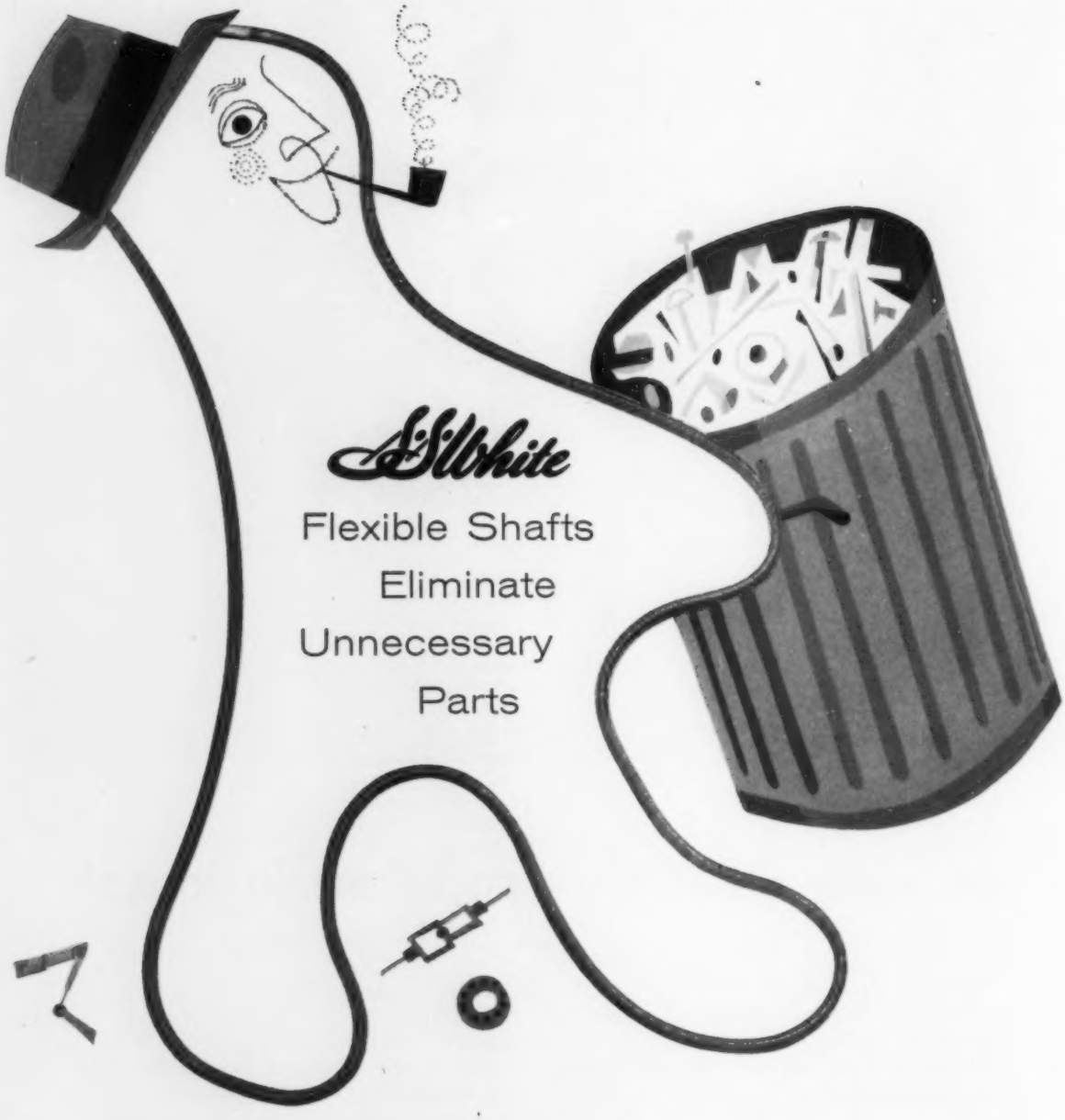

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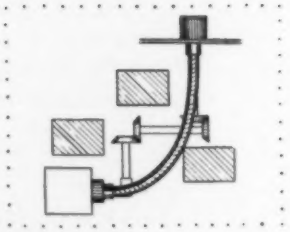

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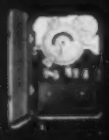

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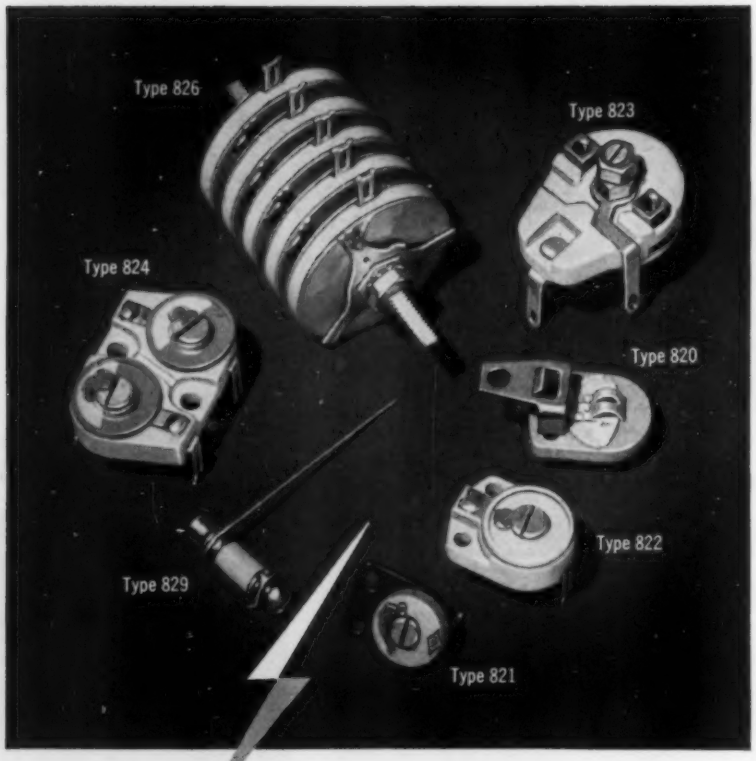

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Circle 120, inside back cover

Motor Operated Shut Off Valve–Data sheet, 2 pp. Contains data on unit designed for high pressure control functions. Hydromatics Inc., Cedar Grove, N. J.

Circle 121, inside back cover

Cluster Fittings–Booklet, 44 pp. Contains data on fitting dimensions, installation and assembly methods. The Weatherhead Co., 300 E. 131 St., Cleveland, Ohio

Circle 122, inside back cover

Nuclear Reactors–Booklet, 8 pp. Contains data and information on various reactor types and how they compare or differ. Industrial Div., Minneapolis-Honeywell Regulator Co., Philadelphia 44, Pa.

Circle 123, inside back cover

Casting Design as Influenced by Foundry Practice–Bulletin 44, 64 pp. Contains data on design, the method of making the pattern, molding procedure, and the characteristics and behavior of the metal in the mold. Meehanite Metal Corp., 714 North Ave., New Rochelle, N. Y.

Circle 124, inside back cover

Swivel Joints–Bulletin 269A, 12 pp. Contains data and diagrams on plane and self-aligning aircraft type joints for hydraulics, pneumatic, oxygen, and fuel service. Barco Mfg. Co., Dept. J27, 500 N. Hough St., Barrington, Ill.

Circle 125, inside back cover

V-Belt Drives–Manual, 66 pp. Contains tables on belt selection, determination of speed ratio, belt speed, hp ratings and design data. Maurey Mfg. Corp., 2915 S. Wabash Ave., Chicago 16, Ill.

Circle 126, inside back cover

Heat Exchangers–Catalog 1254, 12 pp. Contains data and charts on shell and tube units. Young Radiator Co., Racine, Wis.

Circle 127, inside back cover

Fastenings–Catalog 26A, 64 pp. Contains data, illustrations and prices of

(Continued on page 340)

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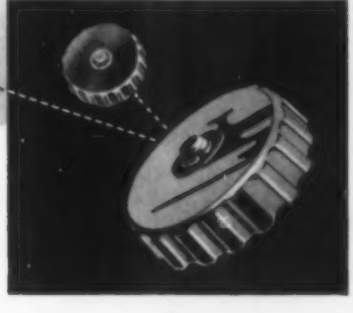

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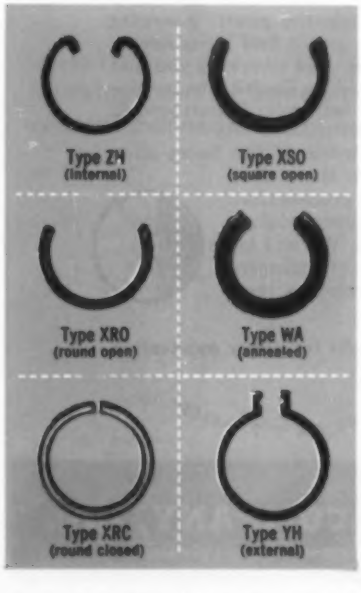

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Helpful Data from
DE LAVAL

How to calculate the efficiency of worm gearing

The efficiency of worm gearing is determined by frictional losses at the tooth contact, bearings and oil seals plus losses from oil churning and windage. A formula for efficiency at the tooth contact may be developed from a consideration of the forces at the contact. Figure 1 shows these forces acting on a developed section of the worm thread. For simplicity the pressure angle has been assumed to be zero.

The coefficient of friction of the worm and gear is a function of the materials, finish, lubrication and rubbing speed. The latter is the relative speed between a point on the pitch surface of the gear and one on the pitch surface of the worm. The coefficient of friction varies very little at high rubbing speeds but rises with increasing rapidity as the speed drops below 500 fpm.

The efficiency formula developed in Figure 1 involves worm lead angle and the friction angle. Figure 2 provides a relationship between friction angle and rubbing speed based on tests made on accurately manufactured gearing consisting of hardened and ground worm and bronze gear operating in oil.

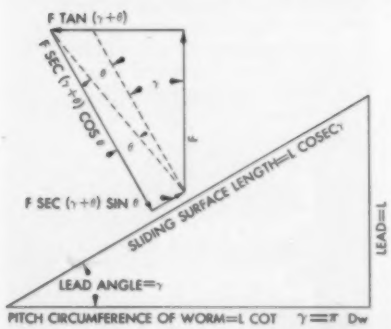
The formula for rubbing speed is:

$$V = \frac{262\ Dw \times \eta}{\cos \gamma}$$

where

V = Rubbing speed – feet per minute
Dw = Worm pitch diameter – inches
η = Worm speed – rpm
γ = Worm lead angle

FIGURE 1.
Development of equation for efficiency at contact between worm and gear


F TAN (γ+θ)
F SEC (γ+θ) COS θ
F SEC (γ+θ) SIN θ
SLIDING SURFACE LENGTH=L COSEC γ
LEAD=L
LEAD ANGLE=γ
PITCH CIRCUMFERENCE OF WORM=L COT γ=π Dw

F=TANGENTIAL FORCE ACTING ON GEAR

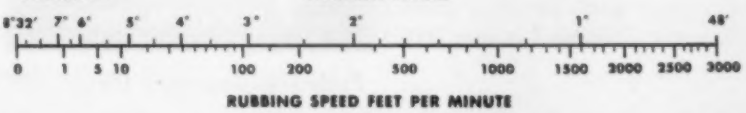
F TAN ($\gamma + \theta$) = TANGENTIAL FORCE APPLIED TO WORM

F SEC ($\gamma + \theta$) COS θ = FORCE NORMAL TO CONTACT SURFACE

F SEC ($\gamma + \theta$) SIN θ = FRICTIONAL FORCE

$$\text{EFFICIENCY} = \frac{\text{WORK REALIZED}}{\text{WORK APPLIED}} = \frac{L \times F}{L \cot \gamma \times F \tan (\gamma+\theta)} = \frac{\tan \gamma}{\tan (\gamma+\theta)}$$

FIGURE 2.



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DL-873

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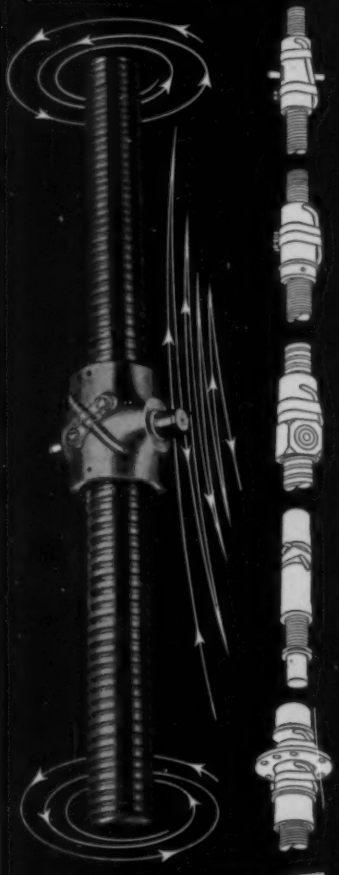

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CLAWSON, MICH.

nuts, bolts, screws, rivets and cotter pins. H. M. Harper Co., Morton Grove, Ill.

Circle 128, inside back cover

Push-Pull Remote Control–Brochure, 4 pp. Contains data and charts on a unit which will manipulate up to 1,000 lb. Controlex Corp. of America, Hangar 18, Westchester County Airport, White Plains, N. Y.

Circle 129, inside back cover

Zinc Alloy Gears and Pinions–Bulletin, 1 pp. Contains data on more than 40 individual units. Gries Reproducer Corp., 400 Beechwood Ave., New Rochelle, N. Y.

Circle 130, inside back cover

Acrylic Rods, Tubes and Shapes–Brochure, 4 pp. Contains data and chart on physical properties, refractive index, compressive and impact strength, dielectric strength, and resistance to chemical agents. Ace Plastic Co., 91-30 Van Wyck Expressway, Jamaica 36, N. Y.

Circle 131, inside back cover

Casting Alloys–Chart. Contains data on the composition of 37 standard alloys and their Navy, S.A.E., A.S.T.M. and Federal specification designations. Henning Bros. & Smith, 91-127 Scott Ave., Brooklyn 37, N. Y.

Circle 132, inside back cover

Metal Powders–Bulletin 561, 6 pp. Contains specifications and charts on properties and applications of powders. Metals Disintegrating Co. Inc., Elizabeth, N. J.

Circle 133, inside back cover

1-5 hp Motors–Bulletin GEA5980, 12 pp. Contains data on production testing techniques and motor construction features. General Electric Co., Schenectady 5, N. Y.

Circle 134, inside back cover

Shaded-Pole Motors–Booklet GEA-6134A, 12 pp. Describes motors for fan and blower applications in ratings 1.5 w through ¼ hp. General Electric Co., Schenectady 5, N. Y.

Circle 135, inside back cover

Lubricated Plug Valves–Catalog, 28 pp. Contains data and diagrams on 100 per cent pipe area, venturi, roundport, and diamond port valves in a variety of metals for 150 lb steam

(Continued on page 344)

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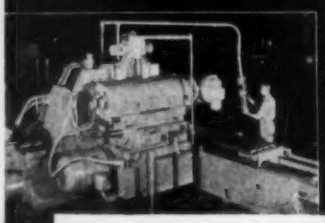

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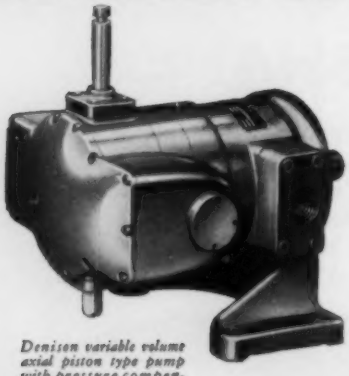
Precision control for a metal monster



Denison variable volume axial piston type pump with pressure compensating control, key to this hydraulic system for Adamson United Press.

● To Denison Engineering went the task of designing accurate, foolproof control equipment for this huge compacting press built by Adamson United, Akron, Ohio. Covering more than 40 square feet of platen area, the press has a 40-inch ram designed to operate on a 2300 psi hydraulic system.

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working pressure, 200 lb oil-water-gas, and ASA 150 and 300 lb classes. Homestead Valve Mfg. Co., Coraopolis, Pa.

Circle 136, inside back cover

Fastenings—Catalog, 24 pp. Contains illustrations and diagrams of screws and bolts ⅛ to 3 in. dia. H. M. Harper Co., Morton Grove, Ill.

Circle 137, inside back cover

Push-Pull Controls—Booklet, 30 pp. Contains data and diagrams on flexible and rigid controls. Arens Controls, Inc., 2017 Greenleaf St., Evanston, Ill.

Circle 138, inside back cover

Relays and Switches—Catalog, 10 pp. Contains data on approximately forty different units ranging in size from standard to miniature. Jaidinger Mfg. Co., Inc., 1921 W. Hubbard St., Chicago 22, Ill.

Circle 139, inside back cover

Enclosed Switches—Catalog 77, 24 pp. Contains data and diagrams on units for airborne equipment. Micro Switch, Freeport, Ill.

Circle 140, inside back cover

Fluid System Specialties—Catalog 4395, 4 pp. Contains data and diagrams on clips, coils, snubbers and gages. Parker Appliance Co., 17325 Euclid Ave., Cleveland 12, Ohio.

Circle 141, inside back cover

Aluminum—Bulletin, 16 pp. Lists sizes and weights of rod, bar, sheet, coil, plate, tubular and building products. Joseph T. Ryerson & Son, Inc., Box 484, Jersey City 3, N. J.

Circle 142, inside back cover

Sheaves—Catalog 83-A, 16 pp. Lists 739 different stock sizes from 3.4 in. to 6 ft. dia. Fort Worth Steel & Machinery Co., P. O. Box 1038, Fort Worth, Texas.

Circle 143, inside back cover

Flexible Couplings—Catalog, 24 pp. Contains dimensions and specifications on standard, double and radial units. Morse Chain Co., Ithaca, N. Y.

Circle 144, inside back cover

Aluminum Mill Products—Booklet, 24 pp. Contains data and charts on pig, ingots, sheet, plate, rod, wire, extrusions, forgings and foil produced

(Continued on page 346)

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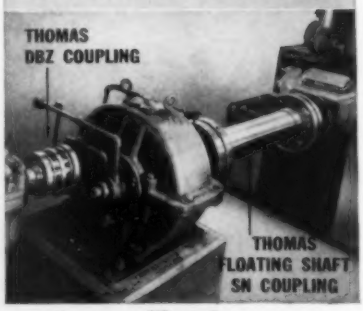

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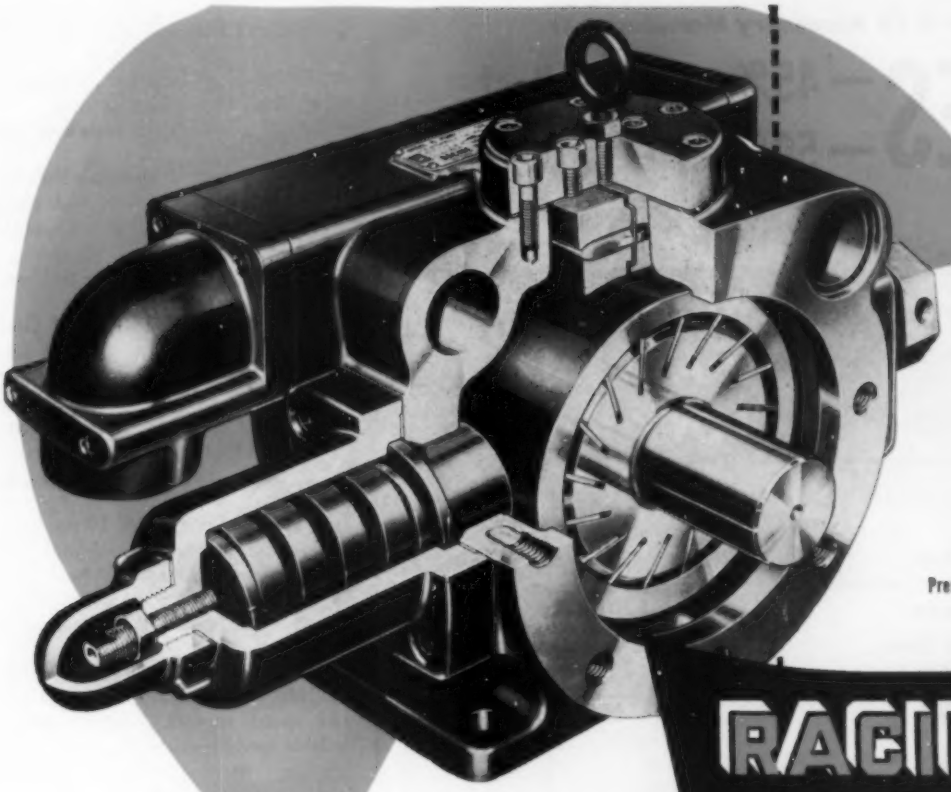

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Circle 145, inside back cover

Carbon-Graphite Material–Bulletin 20, 8 pp. Contains data and chart on material. United States Graphite Co., Saginaw, Mich.
Circle 146, inside back cover

Solderless Wiring Devices and Connectors–Bulletin, 8 pp. Contains data on terminals and connectors for crimping to wire extremities. Electric Terminals Corp., 2021 Center St., Cleveland 13, Ohio.
Circle 147, inside back cover

Sprockets–Catalog 200A, 19 pp. Contains data on flexible couplings and roller chains. Cullman Wheel Co., 1352T Altgeld St., Chicago 14, Ill.
Circle 148, inside back cover

Electric Motors–Catalog, 20 pp. Contains diagrams and charts on normal speed motors, geared motors, variable speed transmissions and speed reducers. Sterling Electric Motors, Inc., 5401 Telegraph Rd., Los Angeles 22, Calif.
Circle 149, inside back cover

Plastic Knobs–Catalog 106, 15 pp. Contains diagrams and charts on bar, ball, pointer and lever knobs. Kurz-Kasch Inc., Dayton 1, Ohio.
Circle 150, inside back cover

Flexible Metal Hose and Tubing–Catalog G-560, 64 pp. Contains diagrams and charts of tubing made of bronze, brass, steel, stainless steel, aluminum and Monel. American Brass Co., 666 S. Main St., Waterbury 20, Conn.
Circle 151, inside back cover

Glass Fibers–Brochure WPD-12, 6 pp. Contains data and charts on flexible, light-weight insulations. L.O.F. Glass Fibers Co., 1810 Madison Ave., Toledo 1, Ohio.
Circle 152, inside back cover

Vulcanized Fibre and Laminated Plastics–Chart compares 34 grades of materials. National Vulcanized Fibre Co., 1056 Beech St., Wilmington 99, Del.
Circle 153, inside back cover

Plastic Pipe–Bulletin CE-56, 8 pp. Contains data on plastic pipe, fittings,
(Continued on page 348)

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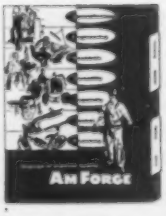

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TPA 109A

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Catalogs and Bulletins.....continued

valves. American Hard Rubber Co., 93 Worth St., New York 13, N. Y.

Circle 154, inside back cover

Epoxy Resin Adhesives–Booklet, 11 pp. Contains data on adhesives for metal bonding and honeycomb sandwich construction. Minnesota Mining and Mfg. Co., 423 Piquette Ave., Detroit 2, Mich.

Circle 155, inside back cover

Gyrol Fluid Drives–Bulletin A-119, 8 pp. Contains data on units in the 7½ through 800 hp range. American Blower Corp., Detroit 32, Mich.

Circle 156, inside back cover

Iron Powders–Booklet, 14 pp. Contains data and specifications on characteristics, strengths, iron sinters, iron-copper mixes and bushings. Republic Steel Corp., 3100 E. 45 St., Cleveland 27, Ohio.

Circle 157, inside back cover

Precision Instruments and Servo Parts–Catalog 11, 128 pp. Contains data and diagrams on gears, couplings, screws, bearings and pulleys. PIC Design Corp., 477 Atlantic Ave., E. Rockaway, L. I., N. Y.

Circle 158, inside back cover

Screw Thread Inserts–Bulletin 748, 4 pp. Contains data and diagrams. Heli-Coil Corp., Danbury, Conn.

Circle 159, inside back cover

Synchronous Induction Motor–Bulletin, 4 pp. Contains data on unit for applications from ¼ to 40 hp. Allis-Chalmers Mfg. Co., 1002 S. 70 St., Milwaukee, Wis.

Circle 160, inside back cover

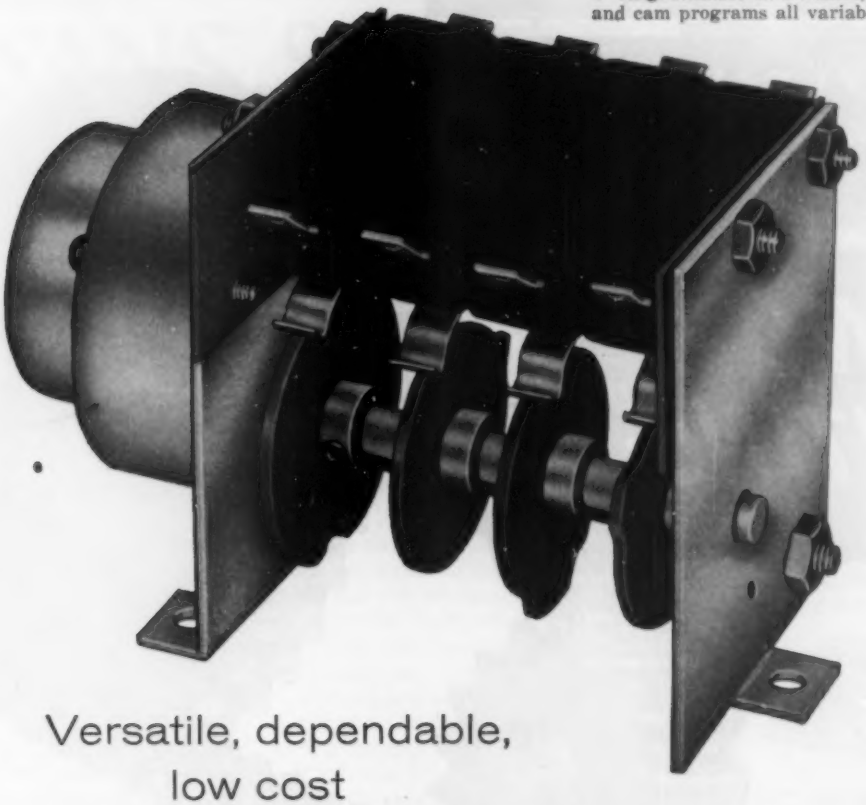
Letterhead Requests Only

Manufacturers who publish following literature ask that requests for copies be made on company letterheads.

Elastic Constants in Structural Design–Booklet 56, 30 pp. Contains data and charts on design with particular application to titanium. Titanium Metallurgical Lab., Battelle Memorial Institute, Columbus, Ohio.

Metal Shapes–Booklet, 24 pp. Contains information on die-formed standard metal shapes. Commercial Shearing and Stamping Co., 1775 Logan Ave., Youngstown 1, Ohio.

Illustrated is a fixed program, 4 switch unit. Actual dimensions: 2½" wide, 3" high, 4" long. Number of switches, motor speed and cam programs all variable.



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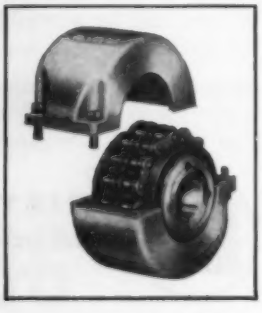


TAPER-LOCK CHAIN COUPLINGS

Accommodates common minor shaft misalignments. Provides strong, compact coupling. Available with covers, for appearance, safety, dirt protection — and lubrication, which increases coupling life.

Ad Libbing by the Editor

One is reminded of the story of the three church members who were appointed as a committee to draw up a temperance resolution. All three of these men imbibed quite freely.

The two young men on the committee of three were commiserating with each other over their woe. They could not figure out how they could draw up a temperance resolution and face their own families, let alone the general public. They had a wonderful reputation as convivial drinkers and it was with a feeling of dismay that they went to the home of the oldest of the three to draw up the temperance resolution.

When the two young fellows arrived at the older man's home they were greeted with a big smile and a hearty welcome and the remark, "Why so glum?" The two young men explained that they couldn't see how they could draw up a temperance resolution and still show their faces around town. They would be the laughing stock of everyone.

The old fellow told them to calm down because he had already prepared the temperance resolution and all they would have to do was sign it. And he guaranteed them they would be in no way embarrassed for having signed the temperance resolution that he had prepared. And thus the temperance resolution was signed. It stated, "We will do all in our power to keep others from drinking."

That is the way so many human actions go. There is always the urge to tell other people how to live their lives, what to do and what not to do. It starts at the cradle and it ends at the grave. It applies in the family, in the town and in the nation. That damnable desire to manage the fortunes and lives of others.

One of the most pathetic instances that I have ever experienced happened to a young man, one of my students. I was supposed to be teaching him heat engines but it was obvious that he was learning practically nothing. I will call him John. In order to help him I asked him to come to my office after school hours and bring his heat-engines book along with him. Such was my usual procedure. By merely glancing through the book I could tell quickly whether or not the man had studied his lessons and whether or not he was interested in the subject. Any man who is interested in the subject and studies it will make notations and marks on the various pages as he progresses through the book.

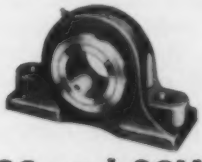
I was not surprised when I leafed through John's heat-engines book to find that each of the pages was shiney and spotlessly clean. Indeed, many of them plainly showed that they had not even been turned. But when I looked at the fly leaves in the book I was quite startled. On one I saw a cartoon of a professor, very obviously myself, at the blackboard attempting to explain an equation. Another fly leaf showed another professor in action. Then there were several other cartoons of a similar nature. And all were so well done that there was no question as to who the characters were that were depicted in the cartoons.

I said something to John to the effect that because he was obviously

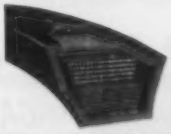
(Continued on page 353)

DODGE PRODUCTS you should know

TAPER-LOCK
ALL-STEEL
CONVEYOR PULLEYS



SC and SCM
BALL BEARING
PILLOW BLOCKS



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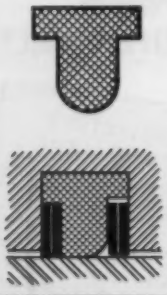

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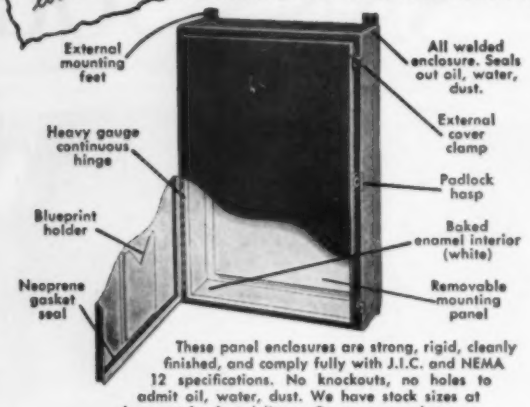

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so much more interested in cartooning than in heat engines, he should by all means develop his artistic ability rather than attempt to build a career as an engineer. And then he unfolded to me a most pathetic story.

John's father was a famous engineer. He insisted that John should also study engineering and at the same university. And he also decided that John should take the same course that he had taken thirty years previously. Now John had no aptitudes for engineering. But he did love to sketch.

Christmas vacation came and John went home to Philadelphia and asked his father for $25.00 to buy his girl a Christmas present. This the father refused to do, not because he didn't have the money but because John had failed in many of his subjects at college.

But John was determined to get money for his girl's Christmas present, so he took a sketch pad and pencils and went down to the Bellevue-Stratford Hotel in Philadelphia. He saw a young couple coming through the lobby, stepped up to them and asked permission to make a sketch of them with no obligations for them to buy the result. He made such a sketch. A small crowd gathered around to watch the operation. The young couple liked the sketch and wanted to buy it. John sold it to them for $5.00. Immediately he had more customers and he continued sketching for $5.00 each until the hotel manager chased him out of the hotel because of the congestion created by the crowd watching John.

John's girl received a better Christmas present than John had initially planned to give her. That is the story John unfolded to me.

In the following spring John became afflicted with that dreaded paralyzing disease called "sleeping sickness." He had to go home and he soon went to a hospital. He did not return to college until the following year. It was a pathetic sight. The ravages of the sleeping sickness were plainly visible. He had lost much of his reflex action. Why the father continued to insist on the boy studying engineering is impossible to analyze and diagnose. It was just the delusion of a misguided parent that compelled this boy to keep on studying subjects which he detested. It was not long before the whole problem was solved.

(Continued on page 354)

Best low-cost way to incorporate variable-speed into machine designs

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The boy again had to leave college because of the ravages of the sickness and a few months later he died. God in his infinite wisdom. . . . . .

Of course the case of John is not the only one of such situations that we see popping up again and again. There are so many people who have the notion that they can impose their will, their way of doing things, their likes and dislikes, upon others. And the worst of these situations develop within the family where the doting parent attempts to compel his son to emulate him when there is neither the will nor the ability to do so.

And we can go beyond the family circle into society and we see the same thing. Ardent prohibitionists demand the right to legislate the lives of others. Because fluoridation is supposed to prevent tooth decay, ardent health fanatics demand that fluorine shall be added to all drinking water, this in spite of the fact that an over dose of fluorine might be harmful and the proposed dose has no beneficial value except in children. And if we were to tell those people that a far better preventative for tooth decay is to prohibit their children to eat candy or to require that the children brush their teeth immediately after eating candy, the suggestion would be considered as an imposition. If it were suggested that children should drink an abundance of milk and fruit juices, those same meddling individuals would raise their hands in holy horror, screaming that such legislation would be an interference of their personal liberties. It is wonderful how irrational the human animal can be. And it is something that must be kept in the forefront whenever anything is being developed for the use of humanity.

The desire for power can be boundless. "Drunk with power" is an apt expression that is only too true. Dominion over time, space, all life on earth including fellow man, is an ultimate to which too many aspire, and none ever reaches. Even if the individual never expects to exercise the power, he wants it, demands it, and takes it if he can get it. As an example, the horsepower of the American automobile has been increased to the point of being almost ridiculous. The unquenchable thirst for power, enough power to gloat over and use it or abuse it, as the whim might suggest. —G. F. N.

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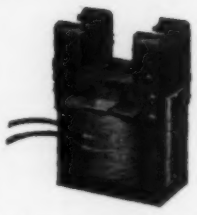

NA-726 solenoid; 16 lbs. at 1" stroke, 100% voltage.

G-200 line of solenoids. Replacement for all sizes of General Electric Co.'s CR-9503-200 line of solenoids.

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ABSTRACTS

Germanium Rectifiers

The semiconductor rectifier is best applied to electrochemical and related steady loads requiring a potential below 250 v where regeneration is not involved. The mercury-arc and mechanical rectifiers find their best application in the electrochemical industry, where ratings of 250 v or higher are used.

The power germanium cell is made from a 0.020-in. wafer sliced from a highly purified single crystal of germanium. Ferni discs are soldered to each side of the water. On one side indium is a constituent of the solder. Indium alloys with some of the germanium create a barrier layer junction within the germanium wafer across which electrons flow more freely in one direction than the other. When properly cooled, this rectifier can be used at current densities almost 1,000 times higher than selenium and will withstand a much higher inverse voltage per cell than either selenium or copper oxide.

Forward voltage drop of a germanium cell is low while the ratio of forward to reverse resistance is in the order of 1:400,000, which far exceeds the ratio of most other metallic rectifiers. These characteristics produce high efficiency and low voltage regulation. The rectifier cell has an efficiency of 98 per cent, when operated at maximum rated voltage. Operation at the high current density means that the rectifier active element can be small. A germanium cell the size of a dime can rectify an average half-wave current of 83 amp when mounted on a properly cooled radiating surface.

Although the losses are small, the heat generated in this small area must be dissipated rapidly. To dissipate the heat and provide an electrical connection, the cell is usually mounted on a copper block with attached radiating fins. A flexible braid is provided for the second connection. High inverse-voltage ratings permit use of single cells in a full-wave bridge for d-c outputs to 75 v.

When voltage greater than 75 is

(Continued on page 358)

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required two individual power supplies are connected in series, giving a max output of 150 volts. Individual cells can be operated in series for higher output voltages. Where output ratings higher than 150 v are required, series operation of cells is more economical than the use of multiple transformer windings.

The earliest installations were forced air cooled; liquid cooling was later adopted to obtain maximum output in minimum space. When liquid cooled, 24 cells are usually arranged in a tray filled with an insulating liquid. A standard water-cooled heat exchanger removes the heat.

A recent improvement in cell design has produced the hermetically sealed cell which greatly increases cell protection against moisture and eliminates the insulating coolant. One mounting type utilizes a block of aluminum with prongs in direct contact with cooling water. The aluminum mounting doubles as a cooling water pipe and electrical conductor. No heat exchanger is needed unless the available cooling water is corrosive.

Sustained severe overload causes permanent cell damage; therefore high-speed current limiting fuses are installed in series with individual or pairs of cells. Each fuse has a companion trigger fuse, which provides visual indication and alarm when any fuse opens.

When the primary a-c power is less than 1,000 v, transformers are installed in the rectifier cubicle. For higher voltages the transformer is a separate unit especially designed with secondary windings to suit the rectifier. An enclosed busway connects it to the rectifier cubicle.

Electrochemical applications usually require a wide range of rectifier output voltage adjustment. Sometimes manual adjustment by transformer taps or manual operation of an induction regulator is sufficient. More often, the chemical process requires close regulation of output voltages or current over an adjustable range. Induction voltage regulators, step voltage regulators, or load-ratio-controlled autotransformers, equipped with necessary automatic control features, are often supplied with a rectifier for a specific application. The saturable reactor is also widely used because

(Continued on page 359)

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it offers infinite adjustment over a wide range and is also adaptable to automatic regulation. For rectifiers rated less than 200 kw, the saturable reactor is often more economical than other methods, particularly where a wide range of adjustment is required.

After more than 5 years of life tests and 2½ years of operation of industry, there is little sign of germanium rectifier aging. Efficiency remains 88 to 95 per cent, depending on operating voltage and auxiliary equipment included.

Abstracted from "Industrial Uses of Germanium Rectifiers" by R. M. Crenshaw, General Electric Co., San Francisco, Calif.; *Electrical Engineering*, Aug. 1956.

High Speed Chain Drives

Most of the advantages of the standardized series of finished steel roller and silent chain, specifically designed and used for power transmission purposes, are well known. Some of the advantages are:

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2. Ability to absorb heavy overloads and shocks.
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4. Long spacing between sprockets is practical.
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Transmission chain has one outstanding characteristic, of which many designers have lately become aware, and are utilizing to full advantage. This is the ability of chain, when fully protected against dirt and moisture, and when properly lubricated, to develop very fine life and wear properties, often surpassing other types of transmission by surprising margins.

The standard roller or silent chain is available in a wide range of sizes, and a size or "pitch" can usually be selected for any commercial speed requirement. It is a fact, however, that the published ratings of those medium and larger pitches of chain suitable for heavy loads exhibit very definite "cut-off" pointts for linear or pitch-line speeds of the chain, which limit these chains to drives

(Continued on page 361)

- **Easy to install...simple to service!**
- **No troublesome protective relays!**
- **No flashing contactors!**
- **No complicated electronic adjustments!**

Specially designed for machines where friction or torque is constant from high to low speed. Motor-generator set, controller and drive motor can be mounted independently, in any position.

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- Totally enclosed Streamcooled construction . . . vernier rheostat for infinite speed control between steps . . . jog switch for machine adjustments . . . reversing switch changes rotation . . . many other features.
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For complete engineering data write for Bulletin SP-600

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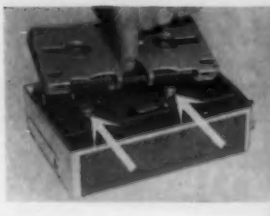
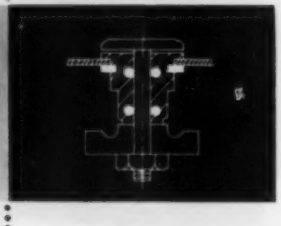
Here is the versatile VERSA-TWIN bearing . . . custom-made by Hartford for the Dictaphone Dictet.





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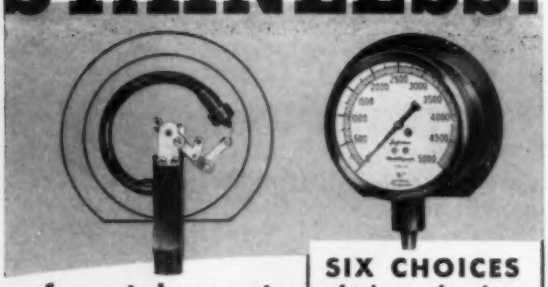

—from inlet to tip

Now the superlative Mastergauge is available in a wider range of corrosion resistant tubes and sockets than any other pressure gauge.

Check the adjoining list. And remember that tube socket and tip are fused into one piece by the exclusive Marsh "Conoweld" process.

Marsh alone combines the "Conoweld" construction, the copper-clad "Marshalloy" case, the finer Mastergauge movement, the Marsh "Recalibrator", the new "Safecase." Ask for data covering your specific needs.

SIX CHOICES
of tubes and sockets

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403 stainless steel tube with 416 stainless tip and socket.

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316 stainless steel tube with 303 stainless tip and socket.

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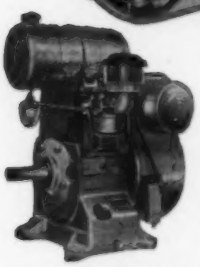

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Onan short-stroke, air-cooled engines give you a combination of performance characteristics which can add *powerful selling features* to your engine-driven equipment. They are designed for continuous service . . . to run hundreds of hours with minimum attention. Short-stroke, low-friction design, extra-large bearing surfaces, Stellite-faced exhaust valves, solid Stellite exhaust valve seats and many other long-life features give you a big premium in trouble-free service.

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Model DRP
Two-cylinder, opposed. 15 H.P. at 2300 R.P.M. 4-cycle. Solid injection, full Diesel. Electric starting. 12-volt generator. Full pressure lubrication.

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of low or moderate revolutions per minute.

This paper defines the factors which create these speed limitations, and shows what has been done in the form of correctional measures to raise this speed ceiling, making available for high-speed, high-horsepower applications, chain drives which in compactness, efficiency, and quietness, are more comparable to heavy duty precision gearing.

Abstracted from "High Speed Chain Drives," by N. C. Bremer; presented before American Society of Mechanical Engineers, Oct. 25, 1956.

Design for Fine-Pitch Wormgearing

This standard is intended as a design procedure for fine-pitch worms and wormgears. Fine-pitch wormgearing is segregated from coarse-pitch wormgearing because fine-pitch wormgears are used largely to transmit motion rather than power. Tooth strength, except at the coarser end of the fine-pitch range, is seldom an important factor. Durability and accuracy, as they affect transmission of uniform angular motion, are of greater importance. Housing construction and lubricating methods are generally radically different in fine-pitch wormgearing. Also, because of their small size, profile deviations and tooth bearings cannot be determined to the same degree of accuracy as those of coarse-pitch worms and wormgears.

This standard covers worms and wormgears with axes at right angles, comprising cylindrical worms with helical threads, the wormgear being hobbed for fully conjugate tooth surfaces. It does not include helical gears used as wormgears. The standard is limited to the case where the hob for producing the gear is a counterpart of the mating worm in regard to its tooth profile number of threads, and lead. The hob dimension differs from the worm principally in that the outside diameter is larger to allow for resharpening and to provide bottom clearance in the wormgear.

Abstracted from "Design for Fine-Pitch Wormgearing," by American Society of Mechanical Engineers, 29 W. 39 St., New York 18, N. Y. American Standard Design for Fine-Pitch Wormgearing (ASA B6), Sept. 1956.

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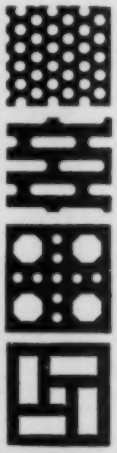

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West Coast Plant, Diamond Perforated Metals Co.
17915 So. Figueroa St., Gardena, California
Los Angeles Area

NEW BOOKS

Bibliography of Product Planning and Development

FRED A. ROTHBERGER, *Research Librarian, 6 x 8 in., approx. 50 pp., paper bound. Published by New Product Digest, Inc., P. O. Box 582, Austin, Texas.*

The entries in this annotated bibliography are selected to function as a reference to books, pamphlets, and periodicals pertaining to business problems encountered in product planning and development.

The Engineering Industries in Europe

A study by Machinery Committee, Office of European Economic Cooperation, 6½ x 9½ in., approximately 210 pp. Available from OEEC Publication Office, 2000 P St., N. W., Washington 6, D. C., $1.50.

An account of the economic trends in the engineering industries of OEEC member countries during the period 1952-1955. Countries covered are Austria, Belgium, Denmark, England, France, Germany, Holland, Italy, Norway, Sweden and Switzerland.

Taken as a whole, the group of OEEC member countries experienced a sizeable rise in productivity over the years studied. Even more magnificent, the rate of increase in 1954 and the first half of 1955 was markedly steeper than in previous years.

Expansion in production was greatest for transport equipment, output in 1955 being 50 per cent higher than in 1952.

Durable consumer goods accounted for one fifth of total production of engineering industries in 1955. Production of consumer goods since 1952 has increased at a more rapid rate than production of non-consumer goods.

Worker productivity has increased as shown by the fact that employment

(Continued on page 364)

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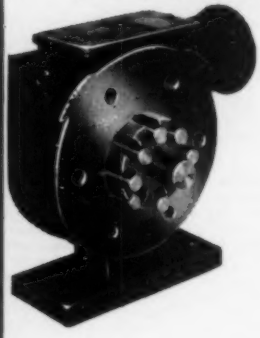
√ tolerance of particle-laden liquids?

√ peak suction for primary pumps?



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Bulletin A-1330 has full data . . . write for it. The roller - rotor design easily handles particles that would jam more tightly - fitted mechanisms — reduces cavitation, allowing higher speed operation* — develops high suction characteristics.

Roller mechanisms permit higher speeds with any oil than most displacement designs.

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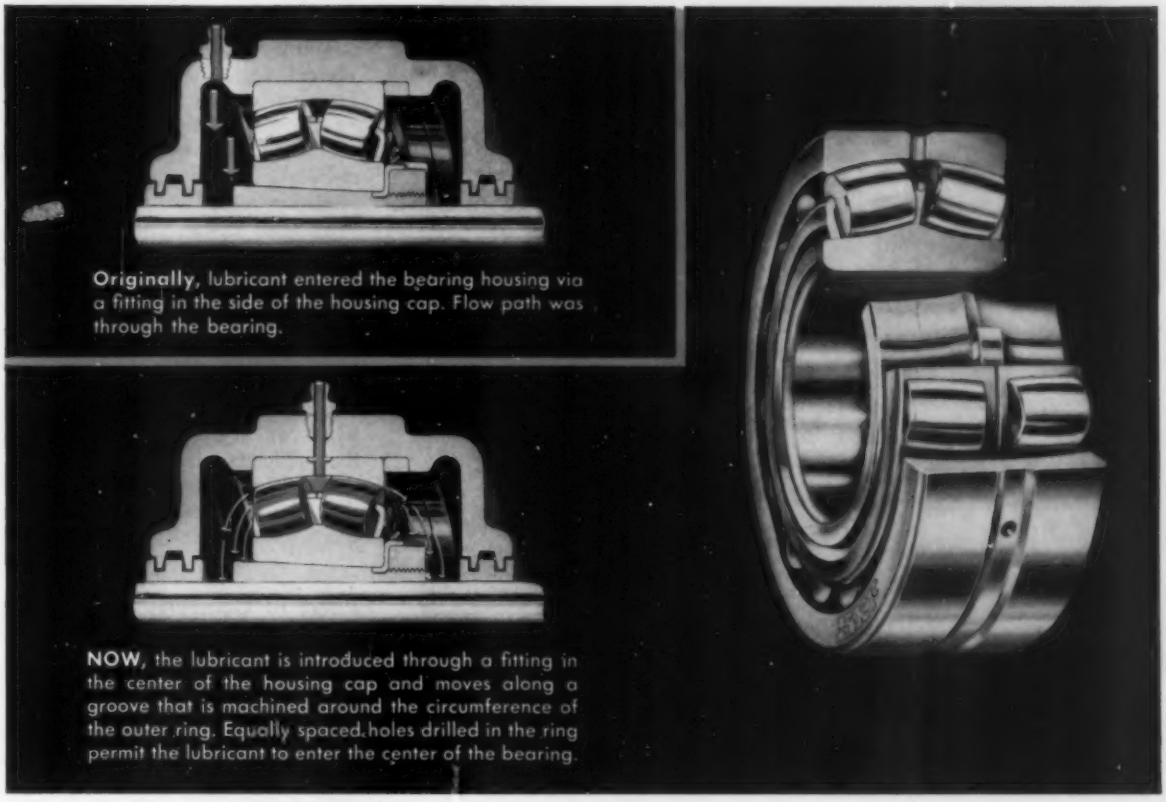
IN LUBRICATING SPHERICAL ROLLER BEARINGS


Originally, lubricant entered the bearing housing via a fitting in the side of the housing cap. Flow path was through the bearing.
NOW, the lubricant is introduced through a fitting in the center of the housing cap and moves along a groove that is machined around the circumference of the outer ring. Equally spaced holes drilled in the ring permit the lubricant to enter the center of the bearing.

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The new design allows the lubricant to enter at the *center* of the bearing and move outwardly – completely covering all working surfaces. Old lubricant is flushed away from the bearing and, with it, any abrasive dust, dirt, moisture, or other impurities.

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bles in rupture tests of notched bars.

This report, second in a series, is sub-titled: "Analysis of Notched-Bar Rupture Life in Terms of Smooth-Bar Properties. Part I: "Preliminary Studies of the Influence of Relaxation and Metallurgical Variables."

Directory of National Trade Associations

JAY JUDKINS, *Chief, Trade Association Div. 8 x 10¼ in., paper bound, 37 pp. Published by Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. $0.40.*

A directory of over 2,000 national trade associations and related organizations of businessmen gives the mailing address and name and title of the key executive. An index facilitates the location of associations in particular product or service fields. Designated by symbols in the new directory are 950 organizations of manufacturers and 350 distributors. Among larger classifications are 250 national associations in the construction and building materials field and 230, each, in the food and textile industries.

Mechanics of Roller Chain Drive

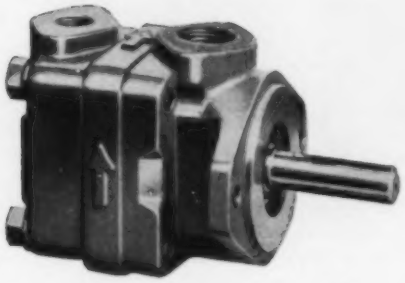
R. C. BINDER, *Professor of Mechanical Engineering, Purdue University, 5¾ x 8¼ in., 204 pp. Published by Prentice-Hall, Inc., Englewood Cliffs, N. J. $5.*

This book treats a roller chain drive under both static and dynamic conditions and contains theoretical and mathematical studies covering such subjects as basic force relations occurring in a chain joint, relative velocity and impact between a chain roller and sprocket when the chain meshes with the sprocket, and effects of sprocket tooth design.

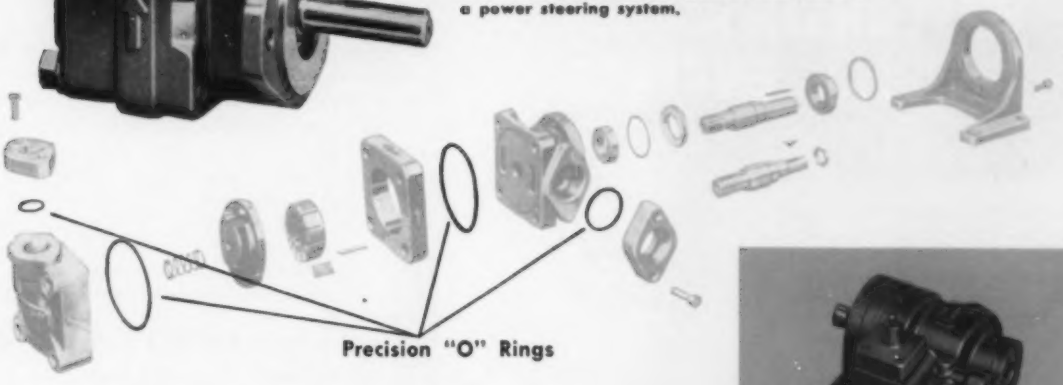
Additional factors analyzed are: angular velocity variation in sprockets, joint frictional losses, vibrations of a span of chain as well as the path which a chain takes in progressing from one sprocket to another sprock-

(Continued on page 369)

Precision "O" Rings protect the Heart of Hydraulic Power Steering Systems.



Precision "O" Rings provide positive hydraulic oil seal in this 1500 P.S.I. Mobile pump in a temperature range up to 160°F. Quality control in "O" Ring manufacture protects this heart of a power steering system.



Precision "O" Rings

There can be no compromise on quality and reliability in hydraulic power steering pumps. VICKERS Incorporated, of Detroit, Mich., the world's largest manufacturer of fine hydraulic pumps, use Precision "O" Rings to assure dependable, long life performance under exacting conditions.

Precision "O" Rings are used in the majority of VICKERS mobile and industrial hydraulic pumps. For VICKERS Incorporated and hundreds of other manufacturers, the use of Precision "O" Rings means economical, efficient, leak-proof operation.

Precision compression molded "O" Rings are rigidly inspected – quality-controlled – meet all military and commercial specifications – the finest made! Precision can furnish the size and compound that fits your product requirements.

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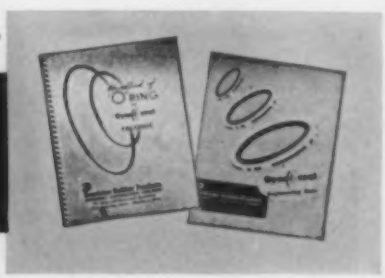
In VICKERS variable delivery piston type pumps, used on industrial machinery, Precision "O" Rings give exacting service in sealing against hydraulic oil pressure up to 3000 P.S.I.

Write for your free copies of Precision catalogs on "O" Rings and Dyna-seals



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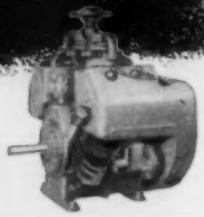
Your customers get...
PERFORMANCE that stands out
STAMINA that stands up

when you specify
WISCONSIN *Heavy-Duty Air-Cooled* **ENGINES**



Whether you design and build farm or construction machinery, oil-field or railway-maintenance equipment, truck refrigeration units, irrigation pumping units, or any of the many other types of equipment that depend on engine power, you're always *right* when you rely on Wisconsin Heavy-Duty Air-Cooled Engines.

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When you specify Wisconsin Engine Power your good judgment is backed by over 2,200 Wisconsin Authorized Service Stations in the U.S. and Canada and in 82 foreign countries. Write for "Spec." Bulletin S-195 and tell us about your power problem.

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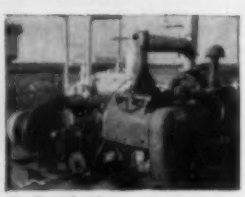

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World's Largest Builders of Heavy-Duty Air-Cooled Engines
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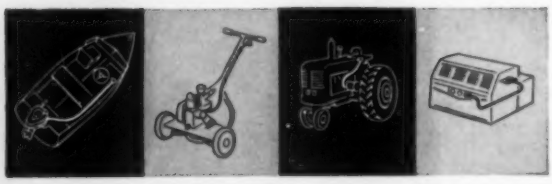
REMOTE CONTROLS...



You'll find that Arens Push-Pull controls offer the simple and low cost answer to control operation of light to heavy load action over long or short distances.

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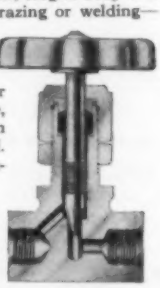

Proofed at 25,000 psi for 10,000 psi working pressure, to 200° F. Semi-needle stem of *hardened* stainless steel. Available with graphited asbestos or Teflon packing.

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et and possible organization of power capacity relations on the basis of wear, vibration and impact. The book was initiated by Diamond Chain Co., Inc., 402 Kentucky Ave., Indianapolis 7, Ind. Copies can also be obtained from this source.

Past Examinations for Professional Engineer

JOHN D. CONSTANCE. P. E., 11 x 8½ in., 70 pp, loose-leaf. *Published by John D. Constance, P. E., 625 Hudson Terrace, Cliffside Park, N. J.* $2.00.

Best method of studying for the engineering license examination must include a review and at least partial work-through of questions from past examinations. A complete file of all three parts of the New York State examinations for the years 1946 through 1956 are here available in one convenient package.

National Reference Guide For the Patent Field

Green Leaf Guide 1956-1957 edition. 6 x 9 *in.*, 71 *pp. Published by Field Publications, Port Washington, N. Y.* $2.

An exhaustive list of companies to which new patentable ideas may be submitted for possible development and marketing. Special symbols are used to differentiate those companies to whom the most new patents were assigned during a recent period. In addition, symbols indicate companies that have shown interest in receiving new ideas in listed fields of interest.

Tentative Specifications On Welding Materials

Published by American Welding Society, 33 W. 39 St., New York 18, N. Y., and American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa. $0.40 *each.*

ASTM A 399-56T-AWS A5.13-56T covers straight length bare and covered surfacing welding rods for use with the oxy-acetylene inert-gas, metal-arc (non-consumable) elect-

(Continued on page 370)

SEALING COMPOUNDS based on "Thiokol" Liquid Polymers safeguard these aircraft electrical connectors from dangerous malfunctioning. (Minnesota Mining & Mfg. Co.)

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Compounds based on "Thiokol" Liquid Polymers are widely used for critical sealing applications such as aircraft connectors and guided missile components. In recent tests of various types of aircraft potting compounds, those based on Liquid Polymers were found far superior to all others.

"Thiokol" Liquid Polymers, the base for these compounds, are synthetic rubbers in liquid form that cure to solid rubbers without shrinkage at normal working temperatures. Once cured, they remain firm and rubbery at temperatures from 65° below to 275° above zero.

"Thiokol" Liquid Polymers provide:

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- Good dielectric properties
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Many uses for polymers

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(Thiokol Chemical Corporation supplies "Thiokol" Liquid Polymer as a raw material. Sources of suitable compounds will be supplied on request.)

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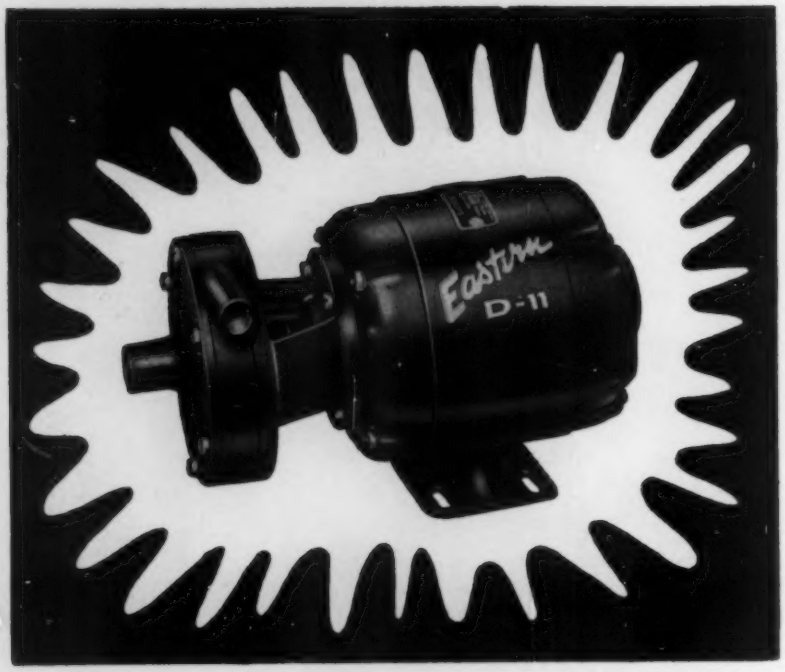
PIONEER MANUFACTURERS OF SYNTHETIC RUBBER



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For complete specifications on all Eastern Centrifugal Pumps, request Bulletin 120-L

EASTERN INDUSTRIES, INC.
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rode), carbon-arc, and atomic hydrogen welding processes. The specification also covers straight length bare and covered surfacing electrodes for use with the shielded metal-arc welding process.

ASTM B 304-56T-AWS A5.14-56T covers bare filler metals (welding rods and electrodes) for the welding of nickel and high-nickel alloys containing more than 50 per cent nickel by the oxy-acetylene, atomic hydrogen, inert-gas metal-arc (nonconsumable electrode), inert-gas metal-arc (consumable electrode), and submerged arc welding processes.

ASTM A 398-56T-AWS A5.15-56T covers welding rods for oxy-acetylene and carbon-arc welding, and covered electrodes for shielded metal-arc welding of cast iron, including gray cast iron, malleable iron, and some alloy cast irons.

Machinists' Ready Reference

C. WEINGARTNER, *Ann Arbor, Mich.*, 4 x 6 *in.*, 139 *pp. Published by Prakken Publications, 330 Thompson St., Ann Arbor, Mich.* $1.50.

Handy little volume containing nearly 100 selected reference tables and charts covering mathematical information; drills; tapers; screw threads; milling, shaping, turning; gears; and weights, gages, and tolerances.

National Standards in A Modern Economy

Edited by DICKSON RECK, *University of California.* 6 x 9¼ *in.*, 372 *pp. Published by Harper & Brothers, 49 E. 33 St., New York 16, N. Y.* $5.

In commemoration of the death in 1954 of Dr. Paul C. Agnew, an editorial committee has asked over thirty experts to write a series of articles on various phases of the standards movement. The articles have been carefully planned to cover the history and present status of standards here and abroad as well as the implications of their use in a mass production economy.

The most impressive feature of the entire standards movement is the quality of self-regulation inherent

(Continued on page 371)

in the creation and successful application of scientific and industrial neers and manufacturers tend to be standards. Inventors, scientists, engiintensely individualistic people and the effort and cooperation required in the development of effective standards is monumental. We are reaping the fruits of that effort today since without these standards mass production as we know it would be an impossibility.

However, standards may also be dangerously restrictive. When applied to consumer products they may constitute a form of trust and laws have been enacted to protect the consumer though it is a tribute to industry that anti-trust laws are rarely resorted to for this purpose. Standards may also obstruct new developments whose appearance had not been anticipated and machinery for the amendment and revision of atiquated standards is necessary if progress is to continue. Certainly legitimate complaints have been recorded but the phenominal speed with which new inventions and developments have reached the consumer in recent years is a testimonial to the versatility of our standards and standards organization.

This book is an informative and stimulating review and so many industries are covered in detail that few readers can fail to find specific references of special interest.

Standards on Rubber Products

6 x 9 *in., heavy paper cover, 746 pp. Published by American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa., ASTM members* $4.40, *non-members* $5.75.

Every ASTM standard relating to rubber and related products is included in this compilation. The volume contains in their latest forms 91 methods of tests, 38 specifications, 23 recommended procedures, and 6 definitions. Of these, 33 are recently revised standards.

Included in the volume are processibility tests, chemical tests for vulcanized rubber, physical tests for vulcanized rubber, aging and weathering tests, and low temperature tests. Standards for automotive and aeronautical rubber, packing and gasket

(Continued on page 373)

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materials, hose and belting, tape, electrical protective equipment, rubber coated fabrics, insulated wire and cable, and hard rubber are also included. Various standards for latex foam, sponge and expanded cellular rubber, rubber adhesives, rubber latex and non-rigid plastics are also to be found in the compilation.

Standards for Circuits and Components

RS-161, 7 pp, $0.70; RS-162, 3 pp, $0.30; RS-164, 5 pp, $0.50; RS-165, 8 pp, $0.80; 8½ x 11 in., paper bound. Published by Radio-Electronics-Television Manufacturers Assn., Engineering Dept., 11 W. 43 St., New York 36, N. Y.

Standards designated RS-161, RS-162, RS-164 and RS-165 cover, respectively, ceramic-based printed circuits, tests for such circuits, fixed paper dielectric capacitors, ceramic dielectric capacitors. Physical and electrical characteristics are given, together with performance standards.

Engineering Societies Directory

8½ x 11 in., paper bound, 35 pp. Published by Engineers Joint Council, 29 W. 39 St., New York 18, N. Y. $3.50.

The directory lists all local, regional and national engineering societies. Contains name and purpose of each organization, as well as the name and address of its secretary. It will be revised and re-published periodically in revised form.

Manual for Rating Motor Fuels

6 x 9 in., 192 pp. Published by American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa. ASTM members $5, non-members $6.75.

This manual was prepared by ASTM Committee D-2 on Petroleum Products and Lubricants (1) to revise and bring up to date the ASTM methods for determining the knock characteristics of motor fuels

(Continued on page 375)

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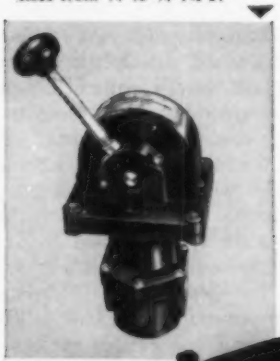
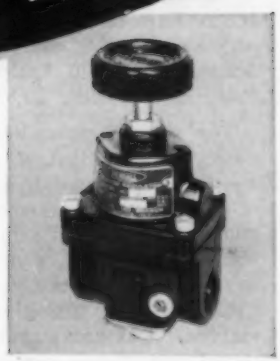


Drift-free, lever set model 3500



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by the research and motor methods, and (2) to better serve users of ASTM knock test engines by providing six appendices, presenting by word and picture, factual information and data on the operation and maintenance of the knock testing equipment. Methods are: Standard Method of Test for Knock Characteristics of Motor Fuels, by the Motor Method (D 357), and Standard Method of Test for Knock Characteristics of Motor Fuels by the Research Method (D 908), commonly referred to as the Motor and Research methods.

Metal Powder Assn. Proceedings

6 x 9 in., paper-bound, 130 pp. Published by Metal Powder Assn., 130 W. 42 St., New York 36, N. Y. $3.

The proceedings includes all technical papers, illustrations and discussions. Some of the topics included follow: "Age Hardenable Brass Alloys through Powder Metallurgy"; "Replacement of Castings by Powder Metallurgy"; "Application of Powder Metallurgy in Nuclear Engineering"; "Powder Metallurgy in the Electrical and Electronics Industries"; "Panel Discussion on Sintered Structural Materials"; "Influence of Lubrication and Die Surface on the Pressing Characteristics of Metal Powders"; "Aluminum Powder Metallurgy Products"; "Ceramic-Metal Friction Materials"; "Manufacturing and Applications of Heavy Alloy".

Bibliographic Survey of Corrosion 1952-1953

8½ x 11 in., 382 pp. Published by National Association of Corrosion Engineers, 1061 M & M Bldg., Houston 2, Texas, non-members NACE-$12.50; members NACE-$10.

Summaries of 3344 corrosion and corrosion prevention articles, books and brochures published in 1952-1953 are compiled in this volume. Material was selected from bulletins published by more than thirty abstracting agencies representing international literature coverage.

Abstracts are arranged in eight main groups: general, testing, charac-

(Continued on page 376)

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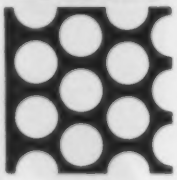

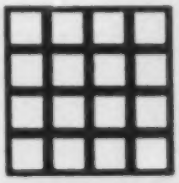

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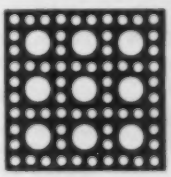

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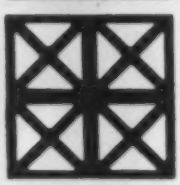

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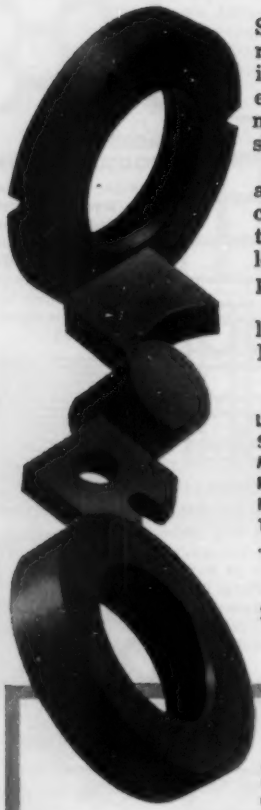

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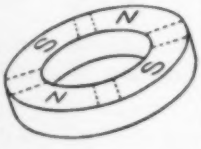

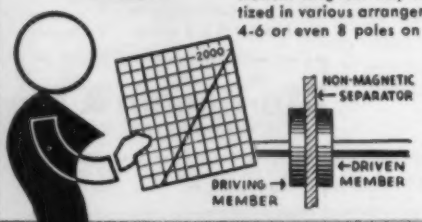

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teristic corrosion phenomena, corrosive environments, preventive measures, materials of construction, equipment and industries.

This is the fifth in a series of NACE bibliographies on corrosion literature. The preceding four volumes, covering 1945 through 1951, contained 12,414 abstracts.

Electric Motors and Controls

5¾ x 9 *in.*, 278 *pp. Published by British Electrical Development Assn., 2 Savoy Hill, London, WC2.* $1.25.

This book describes the various types of a-c and d-c electric motors and explains why a particular type is chosen when maximum productivity, with economy, is required. It reviews the applications of electric power in a wide range of industries, and indicates the best use of the electric motor and associated control gear for economy of operation and increase in productivity. Various types of control equipment, their functions and applications for semi and automatic controls are included.

Numerical Integration of Differential Equations

A. A. Bennett, W. E. Milne *and* Harry Bateman, 5⅜ x 8 *in.*, 108 *pp, paperbound. Published by Dover Publications, Inc., 920 Broadway, New York, 10, New York.* $1.35.

This report discusses the theory of numerical integration of differential equations. A prerequisite is the theory of restricted numerical tables and certain topics connected with interpolation and quadrature, matters treated in Chapter One of this report.

Chapter Two, "Successive Approximations," seeks to provide the historical and logical setting for the fundamental limiting processes used repeatedly in numerical integration and for related developments.

Chapter Three, "Step-by-Step Methods of Integration," explains the technique effective in dealing with ordinary differential equations. In this chapter, the historical and bibliographical order of treatment is subordinated to the expositional type of presentation; a considerable number

(Continued on page 377)

of illustrative examples are included, on the theory that numerical processes are more readily grasped by means of examples than by abstract discussion. The treatment is limited strictly to numerical methods, although many graphical or semi-graphical methods have been developed for step-by-step integration.

Chapter Four, "Methods for Partial Differential Equations," discusses the rapidly widening application of methods based upon numerical differences where more than one independent variable is involved. Commercial engineering and mathematical physics alike are calling ever more insistently for methods of solution for certain problems, admittedly intractable under such elementary naive devices as assumed simple closed analytic formulas for the solution.

Thin Films of Polytetrafluoroethylene As Lubricants and Preservative Coatings For Metals

PB 121161, V. G. FITZSIMMONS AND W. A. ZISMAN, 8 x 10½ *in.*, 30 *pp, paper-bound. Available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.* $1.

When Teflon is applied as thin films to hard substrates, it produces a dry, chemically resistant, all-weather, lubricant. Coefficient of friction between two such Teflon films is 0.04 to 0.05 through a temperature range of -50 C to 230 C. Techniques for applying the film have been developed and tested on various kinds of military equipment, and are described in an appendix.

American Standard on Cap and Set Screws

ASA B.18.6.2-1956, 8½ x 11 *in.*, 21 *pp., published by American Society of Mechanical Engineers,* 29 W. 39 St., New York 18, N. Y. $1.50.

This standard combines in a single document standards for the principal types of cap and set screws, except for socket head products (published in ASA B18.3-1954).

(Continued on page 379)

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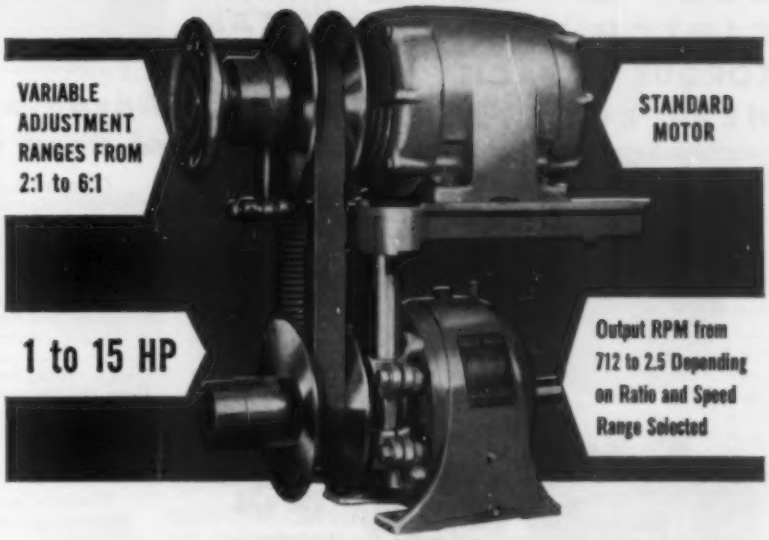
VARIABLE SPEED MOTORIZED DRIVE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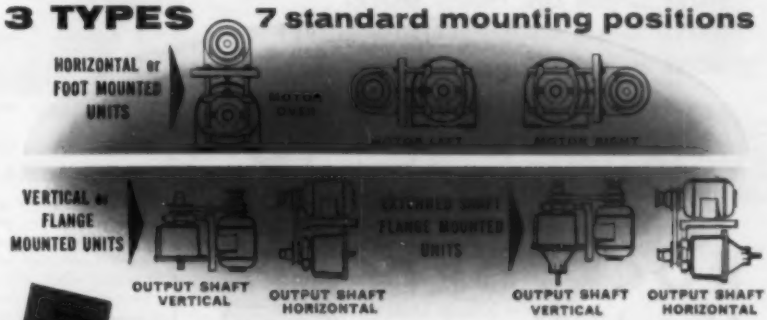

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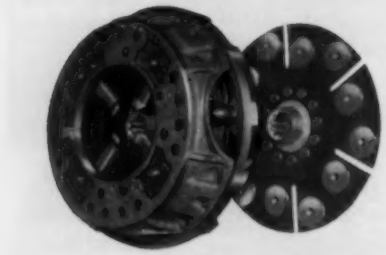

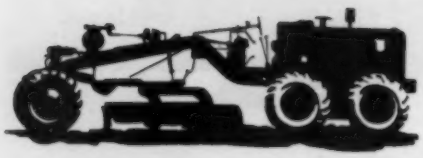

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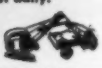

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MORE Torque Capacity (100% MORE)
MORE Heat Resistance (50% MORE)

See this NEW type MORLIFE clutch at the Road Show in Chicago—or get full information how this clutch improves the operation of heavy-duty, off-highway machines, by writing Department E—

"Won't buy a unit that isn't equipped with Durable MORLIFE clutch."

B. W. ENGINEERING MAKES IT WORK

ENGINEERING

B-W

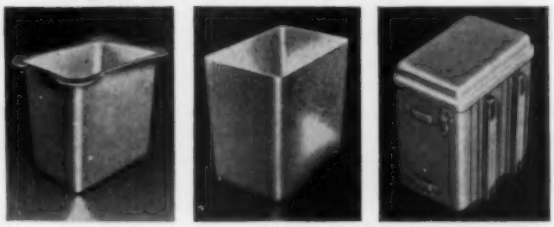
PRODUCTION

B. W. PRODUCTION MAKES IT AVAILABLE

ROCKFORD
Clutch Division
BORG-WARNER
209 Catherine St., Rockford, Ill.
Export Sales Borg-Warner International
36 So. Wabash, Chicago 3, Illinois

CLUTCHES

Light metals design tips



(1) Magnesium case, as drawn; (2) trimmed to 10" depth; (3) finished product.

Advantages and limitations of deep drawing magnesium

Deep drawing of magnesium often results in a more economical product even though initial per-pound material cost is frequently higher than for other metals. Many parts normally requiring 3-stage or 4-stage draws can be made of magnesium in a single draw. Dies can be made of low-cost cast iron or mild steel.

In drawing rectangular parts, a depth equal to one and one-half times the width can be obtained. A corner-radius-to-depth ratio of 1:20 is considered maximum. Deep drawn case in above photos is 10" deep, has ½" corner radii. For round parts, a 65% or 70% reduction can be obtained in a single draw. The following formula will help you calculate the approximate percent reduction on a circular part:

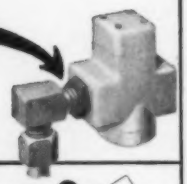
$$\% \text{ Reduction} = \frac{\text{Blank Diameter} - \text{Punch Diameter} \times 100}{\text{Blank Diameter}}$$

Whatever your light metals problem . . . count on Magcoa engineering counsel and fabrication facilities.

MAGNESIUM COMPANY OF AMERICA
LIGHT METALS FABRICATION DIVISION • EAST CHICAGO 27, IND.

STOPS PIPE THREAD LEAKS

PAT. PENDING



Satisfaction Guaranteed Or Money Back TRIAL OFFER

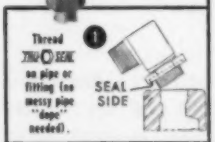
TRU-O-SEAL Fittings are guaranteed to seal pipe thread connections permanently against all oils, practically all known chemicals and gases; to seal under high pressures or vacuum; to withstand —280° to plus 500° F.; to eliminate "overtightening" damage and pipe dope. Available in ⅛" to 2½" pipe thread sizes.

$10.00 Trial Offer No. 1: six ⅛", ten ¼", six ⅜", eight ½" pipe thread TRU-O-SEAL Fittings.

$10.00 Trial Offer No. 2: six ½", ten ¾", four 1" pipe thread TRU-O-SEAL Fittings.

Send order to

TRU-O-SEAL DIVISION
Flick-Reedy Corporation
2002-04 N. Hawthorne Melrose Park, Ill.
"Miller Fluid Power" is also a Div. of Flick-Reedy Corp.


1
Thread TRU-O-SEAL on pipe or fitting (no messy pipe "dope" needed).
SEAL SIDE
2
Thread pipe or fitting 4 threads into port. Point in desired direction.
3
Tighten TRU-O-SEAL to complete leakproof assembly (only light torque required).

It represents the joint efforts of two Subcommittees of Sectional Committee B18, Subcommittee 2 having responsibility for standardization of hexagon head cap screws and square head set screws, and Subcommittee 3 having responsibility for slotted head cap screws and for slotted headless set screws.

Standard ASA B18.6.2-1956 supersedes in part ASA B18.2-1952, in which previous standards for hexagon head cap screws and square head set screws were published, and also supersedes in part ASA B18.6—1947, in which previous standards for slotted head cap screws and slotted headless set screws were published.

Specifications for Some Welding Rods And Electrodes

First specification (AWS A5.15-ASTM A398) covering filler metals suitable for welding gray cast iron, malleable iron and some alloy cast irons has just been issued by the American Welding Society and the American Society for Testing Materials.

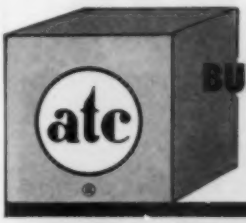
Also published for the first time is a specification (AWS A5.13-ASTM A399) for welding rods and electrodes used for "hard" surfacing. It covers such surfacing materials as high speed steels, austenitic manganese steels, austenitic high chromium irons, copper-base, cobalt-base, and nickel-chromium-boron filler materials.

Symposium on Impact Testing

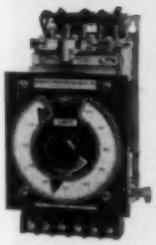
ASTM Special Technical Publication No. 176, sponsored by Committee E-1 on Methods Testing. 9 x 6 in., paperbound, 170 pp. Obtainable from ASTM, 1916 Race St., Philadelphia 3, Pa. $3.50.

Presented here are 14 papers on various aspects of impact testing. Introduced by a general paper on the theory and practice of notched bar testing, the collection covers such diverse subjects as reproducibility of data, alloying effects on transition temperatures of various steels, new impact testing machines, shock testing of completed assemblies and impact properties of concrete.

for time and sequence control in automatic machinery . . .



BUILDING BLOCKS for MACHINE AUTOMATION

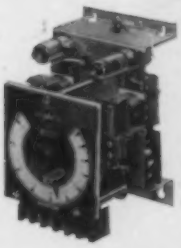


STOP CYCLE DIAL TIMERS

for accuracy . . . flexibility . . . instantaneous reset

Any one of 8 contact circuits are manually selected on the job by adjusting color coded slides. Split-division setting with Vernier. Rated at 25 amps, 115 volts a-c. Repeat accuracy: ½ of 1% of range. "Vernier Set"—13 ranges from 0-15 sec. to 0-60 hrs. "Cycle Progress"—10 ranges from 0-120 sec. to 0-60 hrs.

A

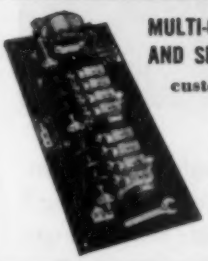


ELECTRONIC TIMERS

for intervals from .02 to 30 seconds

Direct time setting dial. Intervals unaffected by normal line voltage changes, vibration, tube age, high humidity or temperature changes from 0-100°F.

B

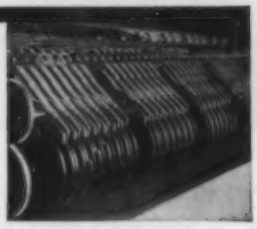


MULTI-CIRCUIT PROGRAMMERS AND SEQUENCE CONTROLS

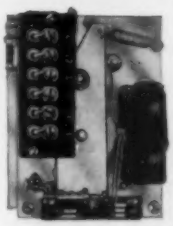
custom built from standard parts

Positive snap action. Completely flexible. Easily and quickly adjusted. Rated at 15 amps, 115 volts, a-c. Repeat accuracy: ½ of 1%.

C Pneumatic



D Electric



TIME DELAYS

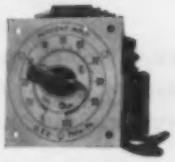
positive acting . . . compact . . . instantaneous resetting

For 1 or 2 loads. Adjustable or fixed period. Rated at 10 amps, 115 volts, a-c. Factory Mutual approved. Twelve standard ranges from .75 sec. to 30 min.

E

CONTROLLERS

F



for economic control of electrically heated equipment

Eliminate power loss . . . control full ON time as percentage of one-minute cycle to proportion power input to load demand. Rated at 20 amps, 115 volts, a-c. Twelve standard ranges from 0-15 sec. to 0-24 hrs.

What are your requirements?

AUTOMATIC TEMPERATURE CONTROL CO., INC.
Subsidiary of Safety Industries, Inc.
5244 Pulaski Avenue, Phila. 44, Pa.

Please send me literature covering:

(A) Bulletin N-11_____ (D) Bulletin N-101_____
(B) Bulletin N-91_____ (E) Bulletin J-31_____
(C) Bulletin N-20_____ (F) Bulletin M-11_____

NAME_____
COMPANY_____
STREET_____
CITY_____ ZONE_____ STATE_____

IN CANADA: POWERLITE DEVICES, LTD., TORONTO, MONTREAL AND VANCOUVER
ALL OTHER FOREIGN: ATC EXPORT DEPARTMENT, 1010 SCHAFF BUILDING, PHILADELPHIA 2, PA., U.S.A.

Do you hear meaningless claims when you buy self-aging Aluminum Alloys?

Federated Tenzaloy is the most widely used of all high-strength, self-aging aluminum alloys because it has the highest yield strength, and it has the best all-around combination of properties. Yield strength is the true measure of a metal's ability to take punishment, regardless of other claims that are made.

When you buy Federated Tenzaloy, you can be sure it will perform as well as its specifications indicate. Tenzaloy is produced under the supervision of ASARCO's Central Research Laboratory, where refining and testing techniques control impurities to parts per million, if required.

Hundreds of foundries and manufacturers use Tenzaloy where heat treating is impractical because of casting design or size. Hundreds more cast Tenzaloy because heat treating facilities are not available.

Why not ask your Federated field man to tell you who uses this metal and how? He will be around to see you soon, and it will benefit you to talk to him.

Federated Metals

Division of

AMERICAN SMELTING AND REFINING COMPANY

120 BROADWAY, NEW YORK 5, N. Y.

PUT HEINZE IN YOUR DESIGNS

F2D Double Unit

F2S Single Unit

TYPE F BLOWER

quiet operation for small air currents

Low in wattage, light in weight, neat in appearance, Type F Blowers are available as single or double units. Supplied with Type F 2-pole shaded pole induction motor. 15 watts, 115V AC, 60 cycle operation. Single unit has load speed of 3100 rpm, 10 cfm. Double unit operates at 3000 rpm, 20 cfm. Durable bakelite housing.

Ideal for any application requiring small current of air and quiet operation — cooling electronic tubes in transmitters, induction heaters, diathermy equipment; for advertising displays, etc.

Heinze blowers are also designed to your exact specifications. Write Dept. F for catalog.

HEINZE ELECTRIC COMPANY

685 Lawrence St., Lowell, Mass.

SUB-FRACTIONAL HORSEPOWER MOTORS AND BLOWERS

OUR READERS SAY . . . . . .

Letters should be addressed to The Editor, *Product Engineering*, 330 West 42nd St., New York 36, N. Y.

Warning! Deadly Poison!

To the Editor:

It is suggested that your magazine publicize the facts about one of the deadliest, yet least recognized poisons, especially as it affects present practices in engineering departments throughout the country.

Apparently, the vapor from carbon tetrachloride frequently attacks the nervous system, kidneys, intestines and especially the liver. The damage may be done either through one heavy exposure or brief repeated exposures.

According to an article by Lawrence Lader in the Oct. 1956 issue of *McCall's Magazine*, doctors believe that carbon tetrachloride can actually be absorbed into the system through the skin. "The vapor from one cupful in a poorly ventilated room has been sufficient to cause death", according to Drs. H. K. B. Allebach and W. R. McPhee, who are quoted in the article.

As you probably know, draftsmen and engineers use this vicious poison daily in generous amounts. They use the solvent to clean their triangles, slide rules, drawing boards, straightedges, drafting machines, instruments and the like. They even use the stuff to remove spots from their clothes and are never concerned about the liberal amounts of the liquid that contact their skin. In many drafting rooms, carbon tetrachloride is used freely, often in poorly ventilated rooms, and most engineering personnel are unfortunately unaware of its danger. —GEORGE E. ROWBOTHAM
Hartford, Conn.

Trademark

To the Editor:

In the article "High Temperature Materials—A Review," which appeared in the Sept. 1956 issue, Table

(Continued on page 384)

Just to name a few . . . and most of the parts we are making to special order don't really have a name! Our real specialty is fabricated wire cloth parts, made to your specifications.

Any metal, almost any size, almost any shape . . . we can probably assemble it for you . . . faster, better and at a lower cost, than you can do it yourself.

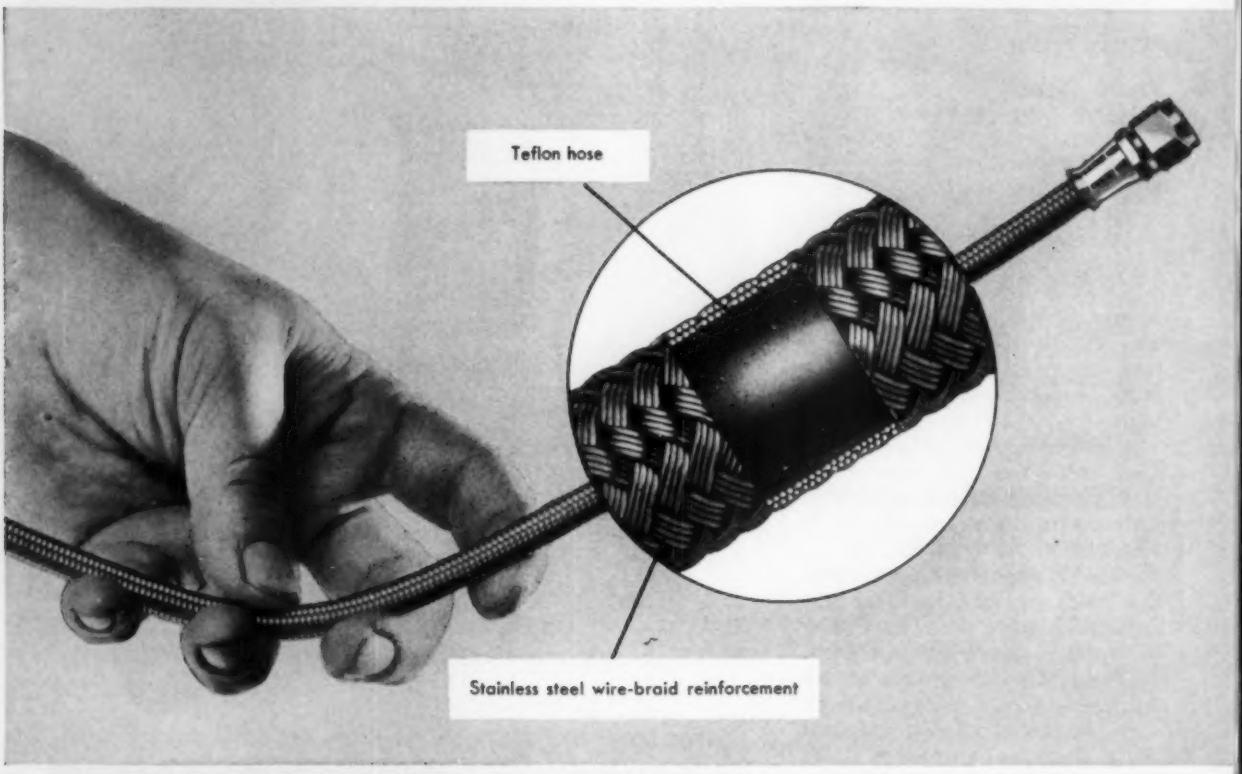
For more information, just send for our latest Fabricated Parts Catalog.

NEWARK for ACCURACY

Newark Wire Cloth COMPANY

351 VERONA AVENUE • NEWARK 4, NEW JERSEY

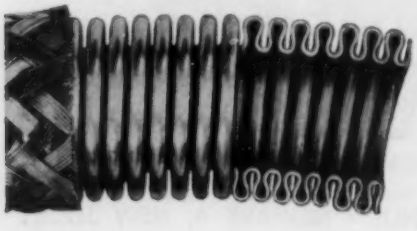
NOW! A Tough Material To
Introducing AMERICAN FLEXIBLE



NAME YOUR PROBLEM. American has the flexible connector to meet it.

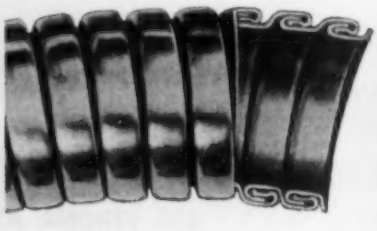
AMERICAN SEAMLESS

Easily installed, low-maintenance, long-life tubing of bronze, carbon steel, stainless steel, Monel, cupro nickel, brass and other workable metals solve most flexible connector problems involving steam, oil, liquids, gases, etc., under pressure; for absorbing vibration in rigid pipelines, connecting misaligned ports; for piping in limited space and service where there is intermittent or continuous flexing.



AMERICAN STRIPWOUND

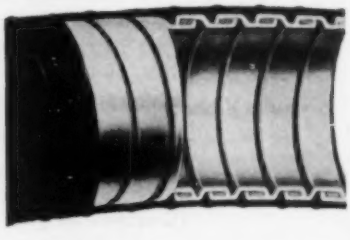
Combines all-metal strength with extreme flexibility, permitting easy installation and handling. Made in bronze for conveying steam and water, in steel for conveying oil, tar, asphalt, etc., and in copper, aluminum, carbon steel, stainless steel, and other metals for special applications. With or without wire braiding.



AMERICAN SEALTITE†

Flexible, liquid-tight conduit. Protective raceway for electrical wiring, made of a flexible galvanized steel core with tough extruded plastic jacket. Completely liquid-tight, resists chemicals. Absorbs movement, vibration, simplifies installation in tight spaces or where there is offset.

†Trademark



Meet Tough New PROBLEMS TEFLON HOSE

Heat-resistant, corrosion-proof, lightweight Teflon* flexible hose absorbs vibration, takes up movement, simplifies offset connections and installations in cramped spaces

FOR AIRCRAFT, GUIDED MISSILES AND ATOMIC ENERGY FIELDS. American Flexible Teflon Hose offers the double advantage of economy and longer life in many applications: fuel lines, oil lines, oxygen lines, hydraulic lines and others.

Properties include complete tightness under high pressures, high resistance to fatigue, torsion and corrosion, light weight and capability of continuous service in temperatue range of—100°F. to 500°F. Unaffected by any known type of fuel, oil, or acid within the temperature range of the hose.

FOR TOUGH INDUSTRIAL JOBS. American Flexible Teflon Hose promises long, economical service in many industrial applications. It is ideal where lines are subjected to outdoor exposure or attack by chemicals, or where high temperatures are a factor—either in the material being conveyed or plant surroundings.

HOW CAN YOU USE AMERICAN FLEXIBLE TEFLON HOSE TO REDUCE COSTS OR IMPROVE PRODUCT SERVICE? American Metal Hose engineers will be glad to consult with your engineers. Write for bulletin TF-100, or call: The American Brass Company, American Metal Hose Division, Waterbury 20, Connecticut. In Canada: The Canadian Fairbanks-Morse Company, Ltd.

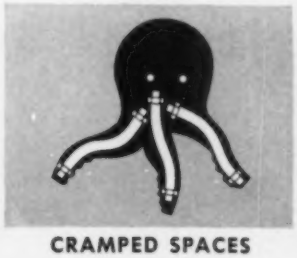
561H2

*DuPont trademark for its tetrafluoroethylene resin

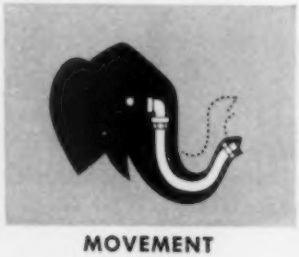
Contact American to solve problems of . . .

VIBRATION

OFFSET CONNECTIONS



CRAMPED SPACES



MOVEMENT

WHEREVER CONNECTORS MUST MOVE

AMERICAN

FLEXIBLE METAL AND TEFLON HOSE AND TUBING

AN

ANACONDA®

PRODUCT

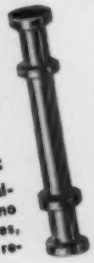
CASE HISTORY 1

REQUIRED:

A dependable supply of this small, machined electrode to meet customer's quality and quantity needs at reduced cost.

HASSALL SOLUTION:

Hassall-designed re-heading process, involving no critical dimension changes, resulted in a 59% cost reduction to customer.



CASE HISTORY 36

REQUIRED:

Less costly manufacturing method for this small stainless steel fluted pin which cost $19.20 per M as a screw machine product.

HASSALL SOLUTION:

Cold forming by Hassall at a cost of $2.95 per M gave the customer an 85% cost reduction on this part.

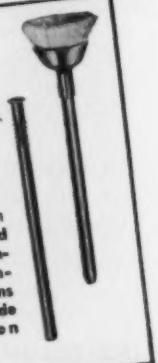
CASE HISTORY 89

REQUIRED:

Customer looking for low cost, high production rate method of producing mandrels for rotary dental brushes.

HASSALL SOLUTION:

Hassall-originated design for cold-heading replaced chamfered end with tumbled, round end; maintained rigid specifications for straightness and made low-cost production possible.



CASE HISTORY 37

REQUIRED:

Bumper bolt with bonded rubber cap for license plate support.

HASSALL SOLUTION:

The large head on this bolt would ordinarily call for screw machining but the two lugs under the head ruled this out. Progressive cold-heading was Hassall's answer.

SPECIALTY MANUFACTURER OFFERS SAVINGS ON SMALL PARTS AND FASTENERS

Multiply these case histories a thousandfold and you'll get some idea of the variety of tough problems we crack, and the savings we effect for our customers in the course of a year.

Our cold-heading process—supplemented by secondary operations—imposes amazingly few limitations on the parts and fasteners we can make. Don't forget that we are not limited to "stock" sizes. These illustrations show that Hassall—a specialty supplier—can show you substantial savings, better deliveries and technical assistance on your small parts and fasteners.

Proof? Send us your specifications or write for catalog.

John Hassall, Inc., P. O. Box 2233 Westbury, Long Island, New York.

HASSALL

SINCE 1850

NAILS, RIVETS, SCREWS AND OTHER COLD-HEADED FASTENERS AND SPECIALTIES

I on page 189 refers to "Vitallium" and makes a comparison with austenitic steels. The word Vitallium is a registered trademark of Austenal, Inc., and therefore is not a generic term. This trademark is applied only to some of our dental and surgical products and can never be used correctly in connection with any industrial material.—CHARLES A. CERAMI
Austenal, Inc.

To the Editor:

The term Vitallium has been used on the continent as a generic term for cobalt-chromium-molybdenum-tungsten alloys. In fact, the word has appeared in the title as well as the text of British papers. I was unaware that the word was a registered trademark of Austenal. A parallel case is the use of the word Duralumin, which is a registered trademark in England. —ERIC A. BRANDES
Fulmer Research Institute

Ed—We are glad to be informed of the proprietary interest of Austenal in the trademark Vitallium as applied to the United States, and will make sure that any future use we make of the term will appropriately show that it is not a generic term.

Rotary Sliding-Vane Pumps

To the Editor:

As we are regular subscribers to *Product Engineering*, we thought that perhaps you could help us in our search for a design handbook dealing with rotary-vane-type pumps. Two articles were published in *Product Engineering* by a consulting engineer named Warren E. Wilson, in Oct. 1945 and Feb. 1946. Can you tell us whether Mr. Wilson, or any other person or group in the U. S., has written a book dealing specifically with the problems of rotary sliding-vane pumps for both hydraulic and pneumatic applications? If so would you kindly advise us of the references to these so that we can purchase them? —M. LINDSEY
London, England

Ed—Mr. Wilson did have a book published in 1950, entitled "Positive-Displacement Pumps and Fluid Motors." Publisher of the book is Pitman Publishing Co. Another book,

(Continued on page 385)

entitled "Displacement Pumps and Motors," by R. Hadekel, was published in 1951, by Sir Isaac Pitman and Sons Ltd. This book is considered a classic in its field.

Ring Springs

To the Editor:

During recent development work, our design group has encountered problems concerning spring designs. We have found an article "Characteristics of Ring Springs" by Tyler G. Hicks, which appeared in *Product Engineering* (Jan. 1950), most interesting.

As a result, the following questions have arisen. Is any additional information concerning the application of the mentioned ring springs available? Also, can you tell us where Mr. Hicks can be located?

—JOHN UNGVARSKY
Windsor, Conn.

Ed—Copies of articles on springs which have appeared more recently in *Product Engineering* are on their way to you. While they do not deal specifically with ring springs, you may find them helpful. You might also contact the Edgewater Steel Co., Oakmont, Pa. This company manufactures ring springs and undoubtedly will be able to assist you. Mr. Hicks is now with the McGraw-Hill Book Co. and is editor of engineering books.

Unfortunately, copies of the original article are no longer available, except as photostatic reproductions at 40¢ a page.

Correction

To the Editor:

Two errors occurred in Tables I and II of my article appearing in your Oct. issue, page 196, entitled "Applying Single-Phase Capacitor-Start Motors."

In Table I, the heads under "Torque, lb-ft"—"Locked Rotor Starting, Min." and "Breakdown,"—should be interchanged. In Table II, the "Single Phase" and "Polyphase" heads should be interchanged.

Corrected reprints of this article are available from the author.

—J. D. AUBRY
Westinghouse Electric Corp

do YOU use time delay relays?
SUN
RAIN
FUNGUS
SALT-SPRAY
SAND
Do you require ADJUSTABILITY? ... No Problem!
Do you require HERMETIC SEALING? ... No Problem!
Do you require BOTH? NO PROBLEM for the
A. W. HAYDON Company
The A. W. Haydon Co. offers a complete line of
ADJUSTABLE — HERMETICALLY SEALED TIME DELAY RELAYS
for operation under adverse environmental conditions
Write for Bulletin AWH TD401
Bulletin AWH TD401 Describes
6400 Series — DC units
11400 Series — AC units
24300 Series — 400 cycle units
Nominal Range of Adjustment: 8-1
Timers supplied with:
AN connector
Hermetic Adjusting Knob
Glass Window and Calibrated Dial
Illustrated above are a few of the many environmental conditions which these compact timers are designed to withstand. More rigid requirements frequently can be met upon special consideration.
The A. W. HAYDON COMPANY
221 NORTH ELM STREET
WATERBURY 20, CONNECTICUT
Design and Manufacture of Electro-Mechanical Timing Devices

Be SURE of SHOCK PROTECTION for delicate instrumentation
Spun
Jewel bearing
Silicone rubber
Pilot hole
Screw setting
Pennies invested
Thousands saved
Bird
jewels with resilient silicone rubber or spring cushions provide inexpensive shock resistance for any instrument. Bird provides variable cushioning to suit different operating conditions; mountings to any specification; controlled movement of jewel.
Spun
Jewel bearing
Spring
Screw setting
Bird Cushion Jewel Assemblies add the necessary safety factor to your instrument production, eliminating waste and tear-down because of poor judgment in bearing adjustment.
Let actual tests prove the superb performance of Bird Cushion Jewel Assemblies. Send specifications and sizes of jewel bearings you require. Bird will send you samples for testing in your own plant. Bird engineers are available for all your small bearing problems.
Over 40 years of serving industry with Quality jewel bearings
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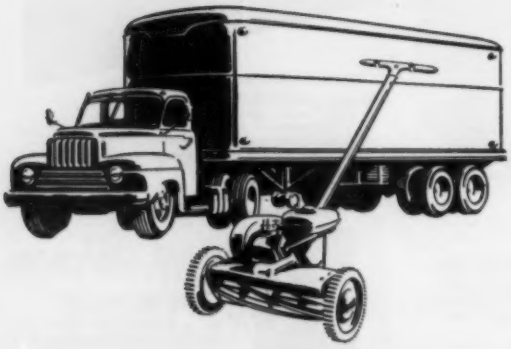
Zenith

HAS A WIDE RANGE OF CARBURETOR TYPES



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On the other hand, if your carburetor requirements are highly specialized, Zenith's engineering experience will prove invaluable in solving questions of placement, efficiency and economy of operation. Just remember, whatever your carburetor problem, it will pay you to look to Zenith for the answer.

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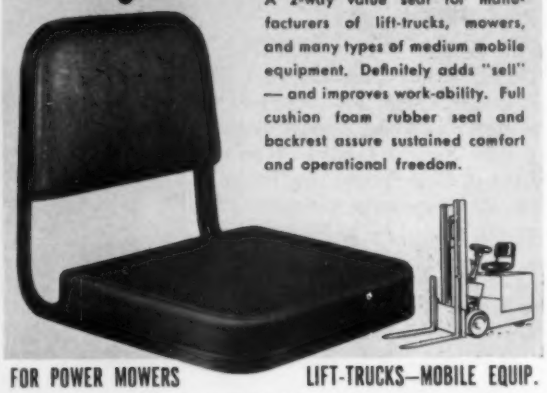

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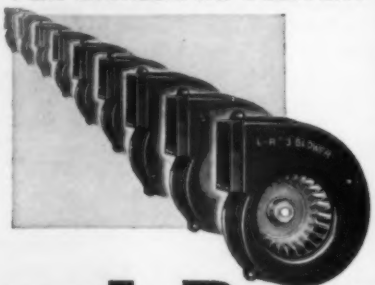

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PRESS PREVIEWS

Anechoic Vault and High-Voltage Test Center Opened

Completion of Westinghouse Electric Corp.'s $13-million expansion program at its transformer division, Sharon, Pa., has increased the division's productive capacity for power transformers by more than 30 per cent. In addition, a new $3.5-million anechoic vault, and a high-voltage test center for transformers has been completed.

The expansion program, which started in 1953, involved construction of a new 200,000 sq ft steel fabricating shop, additions to eight other buildings totaling more than 150,000 sq ft, and construction of the modern test center. Although many commercial tests will be conducted in the test center, it will be used primarily as a research and development tool to aid in the designing of transformers. The new anechoic vault, 70 ft long, 56 ft wide, and 57 ft high, can make complete sound measurements on transformers rated more than 500,000 kva, and weighing more than 400 tons.

Aluminum Rolling Mill

Kaiser Aluminum & Chemical Corp. announced that it will add extensive facilities for the production of

(Continued on page 389)

this movable element unit was Intercast®
— cast-assembled in one operation
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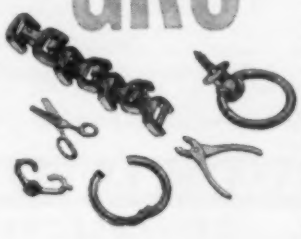

GRC's unique, patented method **intercasts** multiple-part zinc-alloy units with moving elements in a **single, automatic, time-saving, money-saving** operation . . . even continuously interlocked assemblies (like chains). No assembling. The unit leaves the machine—trimmed, ready for plating or immediate use.

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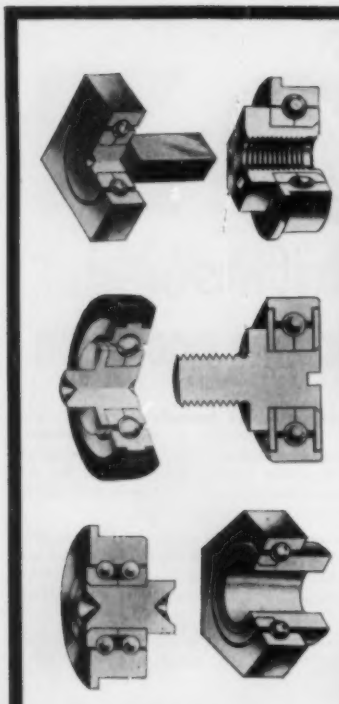

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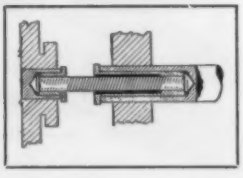

Coupling is used for the transmission of power or control of movement between parts located close together in a piece of equipment. It is not a separate type of flexible shaft but rather an added application of flexible shafting.

The coupling can be composed of either power drive or remote control flexible shafting although the latter is generally used due to the added advantage of its ability to rotate both clockwise and counterclockwise. Generally used between two units which are but a few inches apart, coupling may transmit power between any two parts regardless of their relative positions.

For example, the diagram above shows an advantage in using small lengths of flexible shafting in a coupling application. Although the drive end and the driven end are not exactly in line, the coupling compensates for the difference in alignment between the two.

Many manufacturers use flexible shaft coupling even where parts may be connected by solid shafts because of the savings realized in the initial and the maintenance costs as well as in time and labor.

For complete information on how flexible shaft couplings may help improve your product design, write F. W. Stewart Corporation, 4311-13 Ravenswood Avenue, Chicago 13, Illinois.

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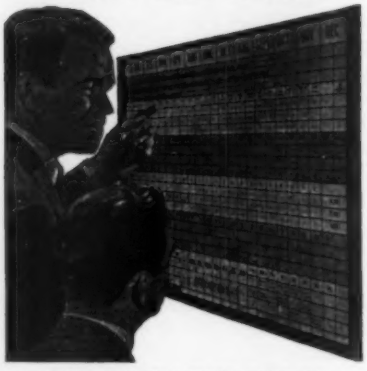

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aluminum plate to the sheet and foil rolling mill now under construction at Ravenswood, W. Va. The additional facilities will include a 144-in. plate mill, heat treating facilities and ultrasonic testing equipment as well as a plate stretcher capable of stress relieving aluminum alloy plate up to 6 in. thick.

The stretcher will be capable of handling a maximum cross section of 550 sq in. Within this over-all limit, gages up to 6 in. and widths up to 12 ft may be stress relieved by stretching, and lengths up to 60 ft may be handled. The plate will be rolled on the new 144-in. four-high reversing mill to be installed and on the 168-in. four-high reversing hot breakdown mill already scheduled for installation at Ravenswood. The latter mill will handle ingots weighing up to 10,000 lb. Also under construction on the 2500 acre Ravenswood site is a 125,000-ton per year aluminum reduction plant, which is designed for possible future expansion to an annual capacity of 220,000 tons of primary metal.

New Laboratories to Study Lubricants, Motors, and Steam Generators

A new bearing and lubricant center has been opened by the General Electric Co., at Schenectady, N. Y., the million-dollar expansion center combines in one location the company's bearings and lubricants development facilities formerly divided between

(Continued on page 391)

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WHATEVER your metallurgical problem, Cannon-Muskegon is equipped and staffed to solve it. Our metallurgists can make the *right vacuum-melted* alloy to fit your need. We can develop and test it in the ultimate in modern research and testing laboratories . . . then produce it to specifications in our modern plant. What's more, Cannon-Muskegon recommends proper handling methods for best results in your application.

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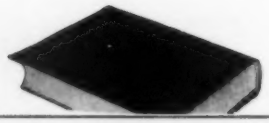

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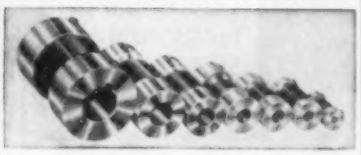

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the Thomson Laboratory of the Lynn, Mass., River Works and the General Engineering Laboratory in Schenectady.

The combined facility has a staff of 30, including 14 engineers, and is expected to double its personnel in the next few years. The center will conduct broad research engineering programs, including the study of air bearings and the use of molten metals and molten glass as lubricants. Additional lubrication work will include investigations and development of oils, greases, synthetic lubricants, solid lubricants and lubricating bearings. Much of this work will be on a cooperative basis with other organizations.

General Electric's Medium Induction Motor Dept., Schenectady, N. Y., will invest $1,500,000 in a developmental laboratory for the creation of new products and improvement in present lines. The new facilities for motor research will include an engineering laboratory, advance engineering test area and a development shop to investigate new manufacturing techniques to parallel product development. The laboratory will undertake applied research and development work in electrical insulation, bearings and lubrication, magnetic materials, metallurgy and welding. The advance engineering facility will be charged basically with the design of new motors and generators.

General Electric Company's Steam Turbine-Generator Dept. has started construction of a $2,500,000 "Overspeed Test Facility." The test building will occupy 8700 sq ft and will be used to spin steam turbine rotors and generator rotors weighing as much as 185 tons at 170 to 200 per cent above their normal speed of rotation. The facility will be used to evaluate the effects of abnormally severe operating conditions on the material properties and design features of the rotors during their performance. The plant will be ready for operation by mid-1957.

Container Plant Expanded

The completion of a $250,000 plant in Burbank, Calif., for the production of precision deep-drawn

(Continued on page 393)

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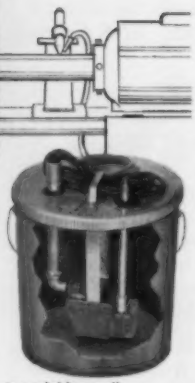

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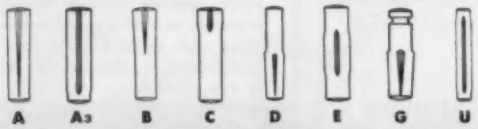

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aluminum cases, boxes, instrument cases and combination carrying cases for the electronics and aircraft industry, was announced by the Zero Mfg. Co., of Burbank. Major production departments include deep-drawing, with hydraulic presses ranging from 150 to 400 tons, fusion and spotwelding, metal finishing, major assembly, and die storage area for more than 1400 stock deep-drawn cases and covers.

New Electro-Mechanical Plant

The completion of a new plant on the West Coast for its Electro-Mechanical Div. has been announced by Erie Resistor Corp., Erie, Pa. The plant will be located in Hawthorne, Calif., and will house equipment for the production of electronic and mechanical assemblies for computers, instruments, communications equipment, missiles, radio and TV, and military equipment.

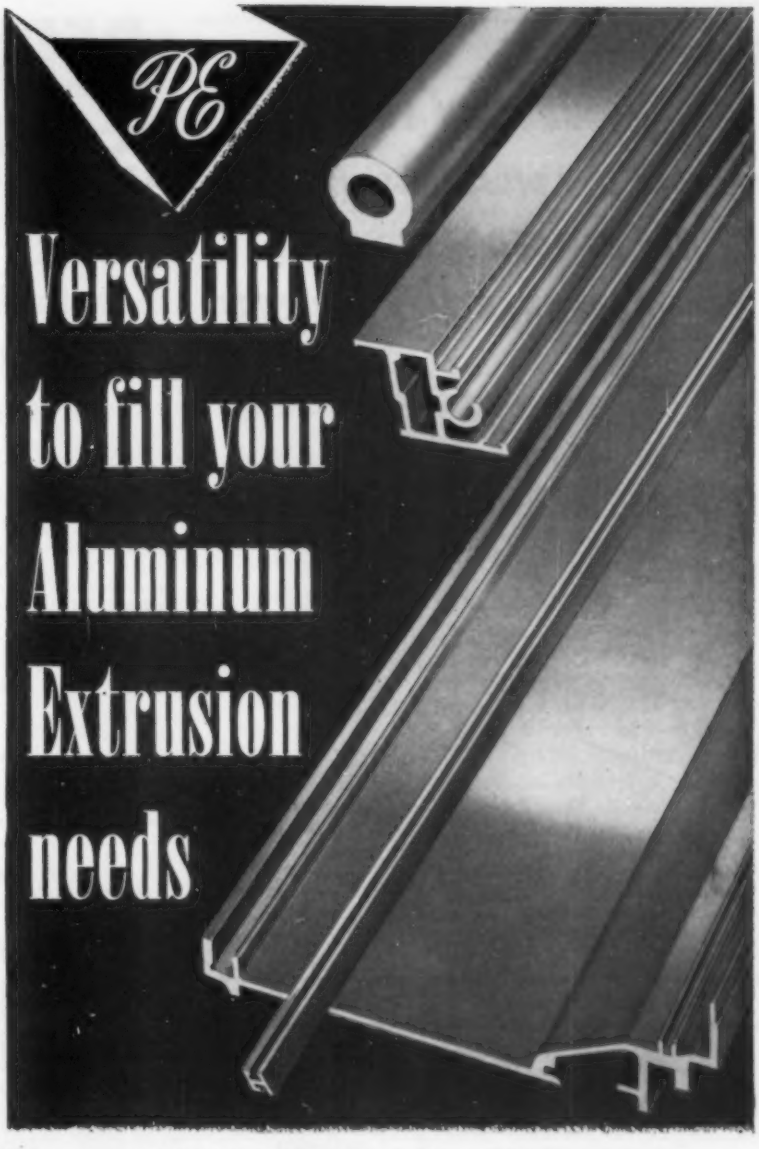
New Company to Produce Metal Tubing

The H & H Machine Co., Inc., Norristown, Pa., successor to H & H Machine Co., has been formed to specialize in the fabrication of metal tubing. Former company produced tools and die design and manufacture. Tubing will be produced in sizes from 0.010 to $\frac{5}{8}$ in. dia in aluminum, copper, nickel, stainless and low carbon steel. Forming operations will include beading, flaring, flanging, spinning, bending, upsetting, swaging, drawing, reducing and expanding.

Lithium Institute Inaugurated

Establishment of the American Lithium Institute, Inc., for the purpose of conducting research on lithium and its compounds, was created by American Potash and Chemical Corp., Foote Mineral Co. and Lithium Corp. of America. The three major U. S. lithium producers stated that the Institute has been formed to direct research on problems of an

(Continued on page 395)



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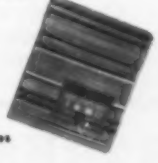

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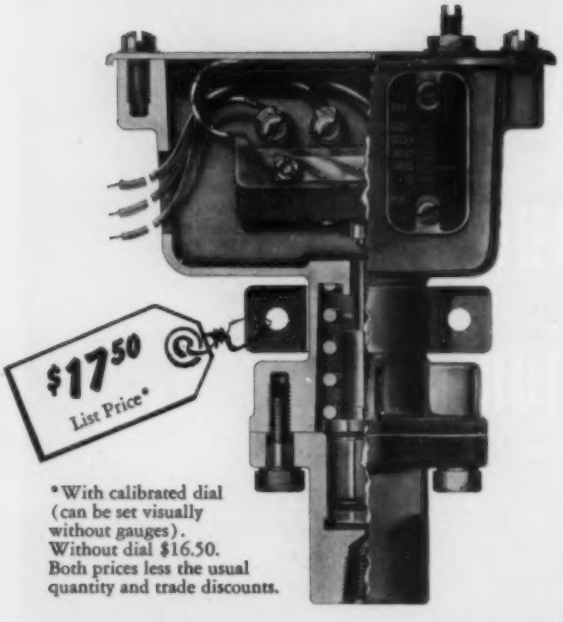

*With calibrated dial (can be set visually without gauges). Without dial $16.50. Both prices less the usual quantity and trade discounts.

WE BUILD IN	WE DON'T USE
RUGGEDNESS Can take surges—(High proof pressures) Continuous operation—(Millions of cycles) No sticking—(in dirty fluid)	**LINKAGES & BEARINGS** Which wear quickly—(cause settings to drift and switch to fail).
LABOR & MATERIAL SAVINGS No return drain piping—(Sealed piston) Mounts where convenient (Operates in any position, Not sensitive to vibration)	**UNSEALED PISTONS** Which add to your installation cost (return piping). Are critical to dirt—(pistons get stuck).

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*REG. U.S. PAT. OFF.

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ELECTRIC FUEL PUMP

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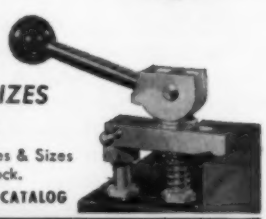

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industry-wide nature, as well as to act as an agency for the correlation and dissemination of technical information on lithium. The Institute, a non-profit organization, will maintain offices in Princeton, N. J. A technical library and literature service will be maintained there.

New Titanium Plant

Ten million pounds per year of titanium sponge is the expected output of a new plant under construction by the U. S. Industrial Chemicals Co., the multi-million dollar plant will be a 175,000 sq ft building in Ashtabula, Ohio. Metallic sodium will be used in the new plant to reduce titanium tetrachloride to titanium sponge by a process developed in U.S.I.'s Research Laboratories. The new process will produce a higher purity titanium sponge than the conventional magnesium reduction process, at a cost lower than that of any existing commercial technique.

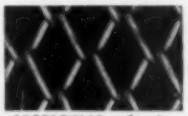
Stainless Steel Building For U. S. Steel

A new office building for U. S. Steel's, Homestead District Works, Munhall, Pa., exemplifies a true stainless steel curtain wall office building. According to company president Clifford F. Hood, this is the first time stainless has been combined into so complete an assembly. 70 tons of stainless have been incorporated in the five story structure. The building also features porcelain enameled panels 4½ ft wide by 12 ft high, the largest of their kind ever fabricated.

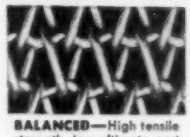
New Development Laboratory

A new development laboratory for the Carbide and Carbon Chemicals Company is being built in South Charleston, West Va. The main building will be a four-story structure with outside walls largely of glass. Separate laboratory units, 26 x 11 ft, are provided for each scientist though in some instances, two men will work together. Specialized facilities have

(Continued on page 397)

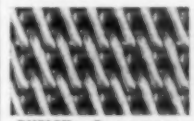


SECTIONAL — Simplest weave, for light loads where low initial cost is desired.

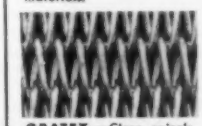


BALANCED—High tensile strength, low ultimate cost belting for operation up to 1300°F. Resists distortion, designed for straight travel.

ROD-REINFORCED — Highest tensile strength and low thermal capacity. It is recommended for high temperatures, up to 2100°F. Undergoes minimum elongation and width contraction.



DUPLEX — Compact structure of great density provides high tensile strength. The close mesh provides smooth surface for carrying small parts and plastic materials.



GRATEX — Close spirals retain the advantages of Balanced weave, while adding strength. For cold, medium and some high temperature applications.

DOUBLE BALANCED — A widely used weave combining open mesh of Balanced weave with the strength of Gratex. For cold, medium, some high temperature applications.

MULTI-STRAND

CORDUROY

INTERWOVEN

How to select WOVEN WIRE CONVEYOR BELTS for Continuous Processing

As you know, woven wire conveyor belts are widely used for combining movement with processing in many continuous operations—heat treating metal parts; washing, blanching and freezing food products; annealing and decorating glassware; washing and curing chemicals and plastics.

However, there is no single type of belt construction suitable for all processes. Some require a smooth belt surface, some exceptional strength, others high corrosion resistance. That's why Cambridge has nine basic weaves available. Each is shown here with the important characteristics of the six most frequently used. The last three are special-purpose weaves for installations requiring exceptionally smooth surface and dense mesh for very small parts.

There are several factors that generally influence selection of weave, mesh size and metal or alloy from which the belt will be woven. Among them are: size, weight and shape of product to be handled; temperatures to which belt will be subjected; presence of wet or corrosive conditions. Even after these have been decided, overall belt construction must be designed to meet individual requirements—type of drive, selvage, support and special surface attachments must be selected.

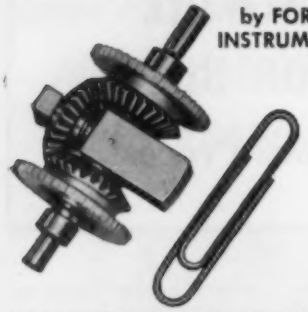
You can see, then, that designing for continuous processing with woven wire conveyor belts is not a simple "nuts and bolts" job. Ramifications build up rapidly to demand the service of a specialist. That's why Cambridge maintains a staff of competent Field Engineers to help you select the Woven Wire Conveyor Belt to make your installation most efficient. You can rely on the experience of these engineers to specify just the right belt for you. In addition, they are thoroughly familiar with basic conveyor design. For the name of your nearest Cambridge Field Engineer, look under "Belting, Mechanical" in your classified telephone book. Or, write direct. Also ask for 130-page Reference Manual of specifications and design information.

THE CAMBRIDGE WIRE CLOTH COMPANY, DEPT. P, CAMBRIDGE 1, MARYLAND.

ON THE SHELF!

SINGLE SPIDER GEAR DIFFERENTIALS

by FORD INSTRUMENT



AVAILABLE IN FOUR SIZES:
⅛", 3/16", ¼", and 5/16" Shaft Diameters

NOTE! Prices of ⅛" units have been drastically reduced.

GUARANTEED SHIPMENT WITHIN:

(WITHOUT END GEARS)		TYPE
1 WEEK	for units with set shaft lengths*	A
3 WEEKS	for units with shaft lengths to customer specs	B
(WITH END GEARS)		
4 WEEKS	for units with stock end gears	C
8 WEEKS	for units with end gears to customer specs	D

(SUBJECT TO PRIOR SALE)

*Note: 5/16" units are not stocked with set shaft lengths.

Ford Instrument produces single spider gear differentials to highest military and commercial standards, for *extreme accuracy* in addition and subtraction, and in servo loop applications. Seven ways superior. Call or wire W. Mohr, Component Sales Division (STillwell 4-9000) for prices, or check and mail coupon below, stating quantity. Data bulletin with performance curves and characteristics will be sent with the prices.

Component Sales Division PE

FORD INSTRUMENT COMPANY

DIVISION OF SPERRY RAND CORPORATION
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Please send me prices on the following:
Circle size of unit desired:
⅛" 3/16" ¼" 5/16"

Circle category for type of units needed:
(Check two if both apply)
A B C D

I want _____ (number) units:

Name_____

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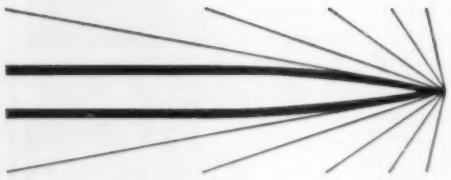
Company_____

Street_____

City_____ State_____



MISSILE ENGINEERS

Many new positions are being created at Northrop Aircraft for missile engineers in a wide range of activity: control, guidance, servo, computers, recording, optical, reliability, electro-mechanical, telemetering and electronics. There's an interesting position for you, at your own experience level, with attractive remuneration and steady advancement, in one of the following groups:

GUIDANCE AND CONTROLS, encompassing research and development of advance automatic guidance and flight control systems for both missiles and piloted aircraft. Specific areas of development include: radio and radar systems, flight control systems, inertial guidance systems, instrument servo systems, digital computer and magnetic tape recording systems, airborne analogue computer systems, optical and mechanical systems, and systems test and analyzer equipment.

FLIGHT TEST ENGINEERING SECTION, which plans the missile test programs and establishes test data requirements in support of the programs. The data requirements are predicated on the test information required by the engineering analytical and design groups to develop and demonstrate the final missile design, and are the basis from which instrumentation requirements are formulated.

The analysis work performed consists of aerodynamic, missile systems, dynamics, flight control, propulsion and guidance evaluation. The Flight Test Engineering Section is also responsible for the field test program of the ground support equipment required for the missile.

FLIGHT TEST INSTRUMENTATION SECTION, which includes a Systems Engineering Group responsible for the system design concept; a Development Laboratory where electronic and electro-mechanical systems and components are developed; an Instrumentation Design Group for the detail design of test instrumentation components and systems; a Mechanic Laboratory where the instrumentation hardware is fabricated; and a Calibration and Test Group where the various instrumentation items and systems are calibrated and tested.

For 17 years Northrop Aircraft has pioneered in missile research and development. As a member of this forefront organization in this growing field, new opportunities for full expression of your initiative and ability will always be yours at Northrop.

If you qualify for any of these attractive positions, we invite you to contact the Manager of Engineering Industrial Relations, Northrop Aircraft, Inc., telephone ORegon 8-9111, Extension 1893, or write to: 1015 East Broadway, Department 4600-P, Hawthorne, California.

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Producers of Scorpion F-89 Interceptors and Snark SM-62 Intercontinental Missiles

been designed for ultraviolet, infrared, mass and emission spectrometry, microscopy, physical testing and X-ray diffraction studies. In addition to the main building there will be a laboratory 240 ft long by 40 ft wide with facilities for studying continuous processes at high pressures.

Metallurgical Research Center

The construction of a two-story, $500,000 Metallurgical Research laboratory will begin this spring at The Timken Roller Bearing Co., Canton, Ohio. Of steel frame, brick and tile construction, the new fireproof laboratory building will centralize under one roof the metallurgical research facilities which are now located in several separate buildings. More than 75 specialists are expected to use the new research center.

Automation Subject At Conference

Growth and a promise for the future of automation was the subject of a panel meeting with the press and five outstanding scientists and business leaders held as an introduction to the Eleventh Annual Instrument-Automation Conference and Exhibit in New York.

Robert T. Sheen, President of Milton Roy Co., and President of the Instrument Society of America, emphasized this growth by pointing out that in the seven years between 1947 and 1954 there had been a three-fold increase in purchases in the automation industries. The ISA has felt a growing concern and responsibility for the problems, both social and economic, arising out of this forced maturity.

Throughout the panel discussion it was evident that the primary concern of all members was the need of properly trained and educated individuals for use in all phases of the new science. From the colleges and research laboratories where new materials, components and mathematical tools are being created through the manufacturers, venders and users of this equipment the lack of personnel

(Continued on page 399)

Miller Phosphor Bronze is consistently chosen for the tough jobs—in this instance a switch part that must withstand an estimated 750,000 "on and offs" without fatigue or fracture.

Miller *specializes* in the tailor-made production of phosphor bronze alloys—in strip, coiled and flat lengths—best fitted to your needs. At Miller, Phosphor Bronze is the main line, *not* a sideline.

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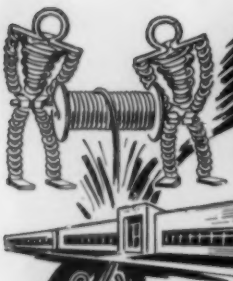

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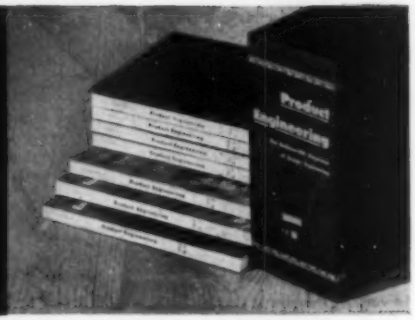

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Expansion and modernization is continuous. Newly designed, high speed production equipment means savings in brush production.

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Send us your brush problems, whether it is a design, a price, a production or delivery problem. Let us show you how Flo-Pac Service will work for you.

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has delayed and will continue to slow progress.

Professor John R. Raggazzini, Chairman, Electrical Engrg. Dept., Columbia University, entered a plea for more industry help to colleges and universities in which the major part of high caliber training and education takes place. It was pointed out that in a similar way industry must train its own employees in the new skills needed in the proper operation and maintenance of automated systems.

Dr. E. W. Engstrom, Senior Executive Vice President, of RCA, was concerned about the social implication of automation. Convinced that we are facing a change comparable to the Industrial Revolution, he felt that only a gradual and controlled changeover to automation would avoid the disastrous economic turmoil inherent in so sweeping a change. However, in the long run he felt certain that each new advance could bring with it even higher employment levels in sheer quantity and that it was the concurrent upgrading of workers' skills that remained the only real problem.

New Divisions

Lord Mfg. Co., Erie, Pa., has established a Special Products Div. for the research, manufacturing and marketing of adhesives, chemicals and other polymers.

Westinghouse Transformer Div., Sharon, Pa., has been further departmentalized by the formation of a distribution transformer department and a specialty transformer department.

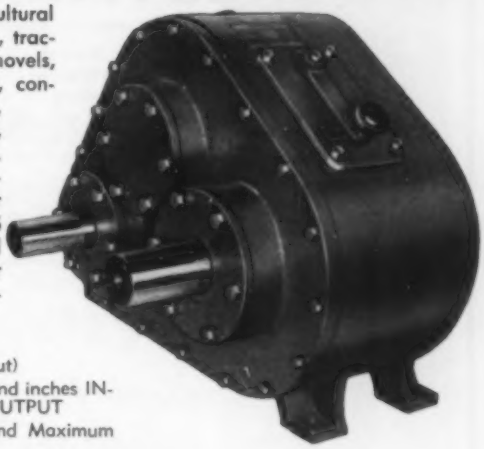
Kieley and Mueller, Inc., Middletown, N. Y., has announced the creation of a Nuclear Power Equipment Div. High temperature, bellows-sealed control valves with self-contained control systems are to be built by this new division for a nuclear development facility.

Name Changes

Parker Stamp Works, Inc., have changed their name to The Parker-Hartford Corp. The company produces tools, dies, molds as well as 2 and 3 dimensional cams for controls.

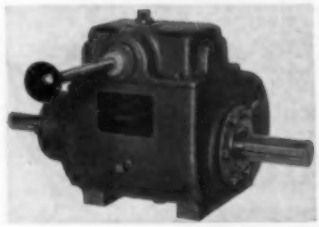
STANDARD TRANSMISSIONS

. . . for industrial and agricultural machinery, automotive trucks, tractors, refuelers, industrial shovels, cranes, shop and lift trucks, concrete mixers, road machinery, diamond drills, machine tools, feed boxes, gear heads . . . send for catalog and complete information . . . for SPECIAL TRANSMISSIONS . . . consult our experienced engineering department for preliminary designs—no obligation.



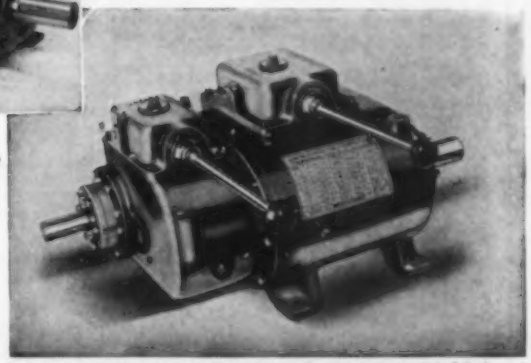
Model 9400
(360 H.P. at 1800 RPM input)
TORQUE RATING: 12,600 pound inches INPUT 96,700 pound inches OUTPUT
RATIOS: 1:1 (with neutral) and Maximum Reduction of 7.67:1
SPEED CHANGES: Overdrive or Reduction (Input and Output shafts from same or opposite sides)

9000-B (1-10 HP
CAPACITY: 5 H.P. at 900 RPM input
10 H.P. at 1800 RPM input
TORQUE RATING: 350 pound inches INPUT 1400 pound inches OUTPUT
GEAR RATIOS: 1:1-2:1-3.14:1-4:1 (special ratios at extra cost)



8100-B (10-20 H.P.)
CAPACITY: 10 H.P. at 900 RPM input
20 H.P. at 1800 RPM input
TORQUE RATING: 700 pound inches INPUT 2800 pound inches OUTPUT
GEAR RATIOS: 1:1-2:1-3:1-4:1 (special ratios at extra cost)

420 (20-40 HP)
CAPACITY: 20 H.P. at 900 RPM input
40 H.P. at 1800 RPM input
TORQUE RATING: 1400 pound inches INPUT 7500 pound inches OUTPUT
14800—Four speed changes, up to the limit of the case, 10:1.
14900—Four speed changes in geometric progression of 1.71 (total reduction of 5.03)



Model 9300 (30-60 H.P.)
CAPACITY:
30 H.P. at 900 RPM input
60 H.P. at 1800 RPM input
TORQUE RATING:
2100 pound inches INPUT 12,600 pound inches OUTPUT

Eight speed changes in Geometric Progression of 1.29 (total reduction of 6:1). Special ratios at extra cost.

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WESTERN MANUFACTURING COMPANY
3400 Scotten Ave. DETROIT 10, Michigan

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It involves the design of a variety of static and moving parts: compressors, combustors, turbines, control components, gear and lube systems.

It requires men with knowledge of high speed machine design, and experience in any of the following fields:

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EE or ME degree plus at least two years experience in electrical-mechanical devices required. Exceptional opportunity for creative work in an expanding industry.

GLA engineers enjoy unusual individual freedom while working for a growing and progressive company near New York's famous vacationland. Salaries are commensurate with experience and ability.

Send resume

Attn:
Mr. R. E. Powers, Personnel Manager

GENERAL LABORATORY ASSOCIATES, INC.

Plant #2, Norwich, New York

WANTED PRODUCTION MANAGER

Reputable metal working company has opening for a production manager experienced in production supervision with the potential to become vice president for manufacturing. Engineering degree desirable but not essential. Experience in metal working or allied industry required involving forging, blanking and forming and metal finishing. Production control experience is desirable. Excellent salary and working conditions. Potential for personal progress. Forward resume of educational and experience background to

P-3736, Product Engineering
Class. Adv. Div. P. O. Box 12, N. Y. 36, N. Y.

Erie Mining Company, in northern Minnesota where there is excellent hunting and fishing, is considering applications for a permanent position as Supervisor of Maintenance for Heavy Duty Equipment.

Applicant should have ME Degree or equivalent with at least five years' of supervisory experience in a responsible position covering the repairing or rebuilding of diesel and electric shovels, large trucks to 35 cubic yards, tractors, and smaller units.

Excellent housing, schools, and churches. Insurance and pension benefits.

Send complete resume and salary desired to:

Industrial Relations Dept.
Erie Mining Company
Box 847
Hoyt Lakes, Minnesota

SR. ACOUSTICAL PHYSICIST
$15,000 PER YR., NO FEE

Experimental and theoretical approaches required —investigating and interpretating acoustical parameters of liquid and solid media in terms of system and equipment application, should have experience involving acoustic transmission and propagation, with familiarity in underwater sound theory, measurement and operational problems.

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Mr. Dan Knott

The RAMO-WOOLDRIDGE CORPORATION

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Dormeyer Corporation, one of the nation's fastest growing and leading appliance manufacturers has immediate openings for an electrical engineer as well as a product design engineer with experience in the design and manufacture of small fractional horsepower motors, both universal as well as the shaded pole types as applied to household appliances such as food mixers, portable tools and heating appliances.

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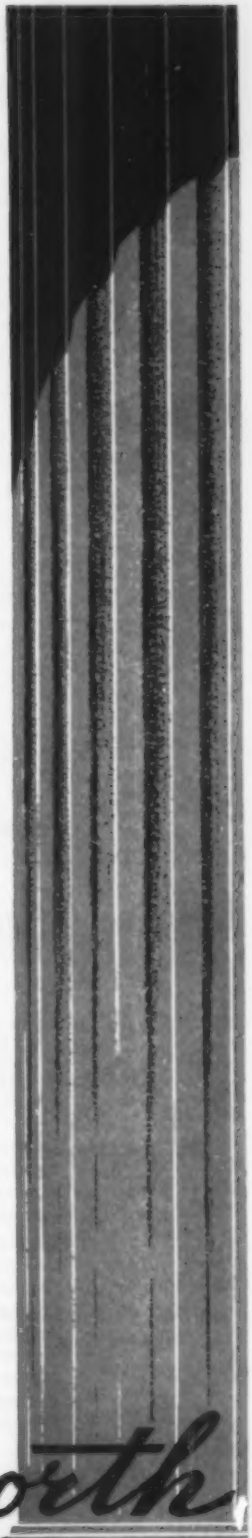

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Index of

PRODUCTS ADVERTISED

In This Issue

A

Accumulators 87

Actuators
Mechanical 39, 340

Adhesives 54, 372

Aluminum Alloys 2, 22-23, 64-65
110-111, 119-120, 380

Aluminum Coated Sheet and Strip
(see Steel, Coated)

Assemblies
Electrical 253
Hydraulic 103, 292, 342

Axles 272-273, 338

B

Ball Joints 34A

Bars
Metal 4, 38, 115, 306, 355

Bearings
Ball 44, 104, 134, 229, 237, 312
343, 358, 360, 363, 388

Jewel 385, 392

Needle 104, 262, 358

Roller .....4th Cover, 24-25, 104, 229
262, 312, 343, 358, 363

Sleeve 306

Belts, Timing 12, 100

Belts, V. 12, 348, 350-351

Benders 110-111

Bi-Metal 364

Blowers 380, 386

Bolts 14, 28-29, 108, 278, 403

Books 390

Boosters 87, 345

Boots .....2nd Cover

Brake Motors 45

Brakes
Electric 235
Mechanical 295

Brass 43

Brazing 110-111

Bronze 43

Brushes 398

Bushings 306, 350-351, 398

C

Cabinets 352

Cam Followers 237, 262

Cams 328

Capacitors 336

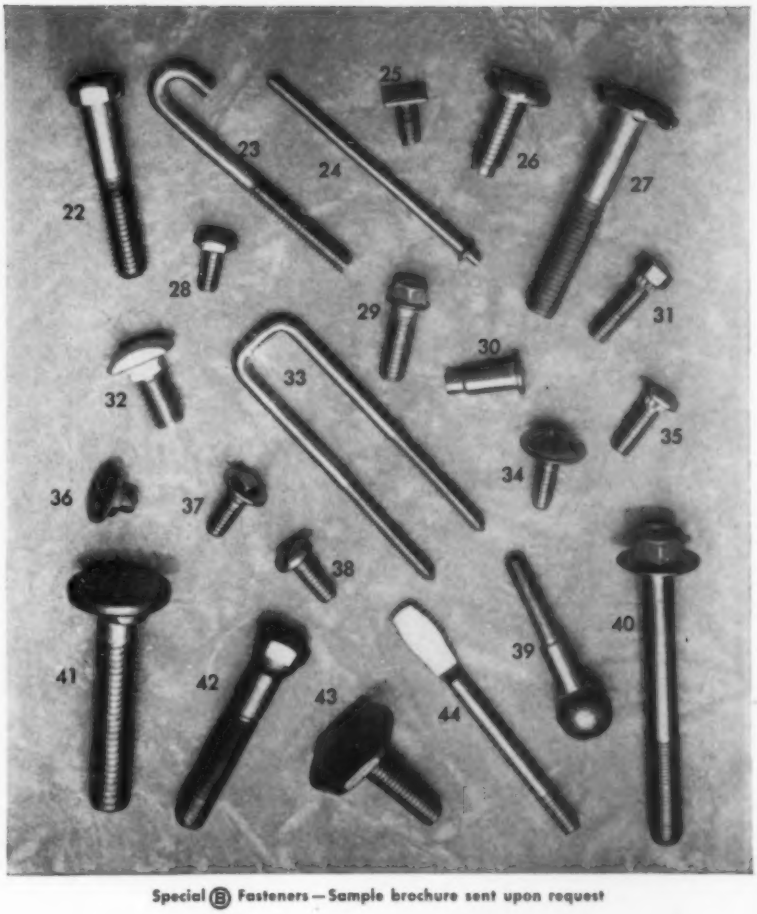
Carbon 88-89

Carburetors 386

Castings 20-21, 291, 355

Castings, Precision Investment..... 80

Continued on p. 404



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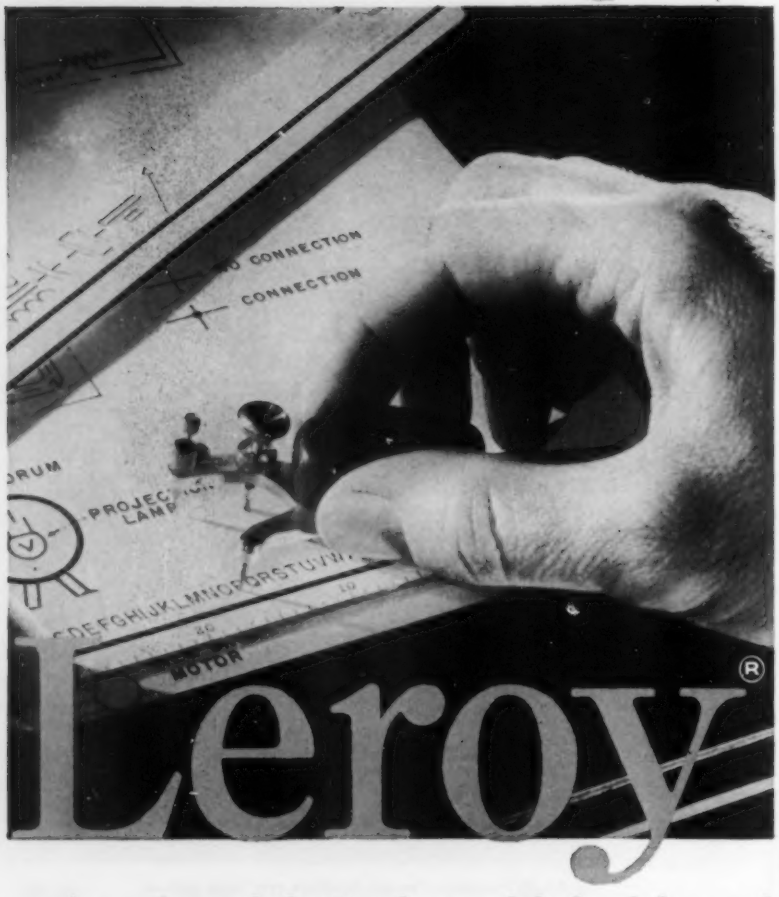

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Index of PRODUCTS ADVERTISED

In This Issue

•

Continued from p. 403

Ceramics 392

Chains
Conveyors 55, 308, 398
Roller 55, 297, 308, 350-351 373, 398
Silent 55

Chemical Treatments 98, 227 250, 296

Chromium Alloys 97

Clad Metals 31, 411

Clamps 365, 374, 394

Clamps, Hose 365

Closures 301

Clutches
Electrical 251
Mechanical 271, 290, 378

Coatings 98, 227, 250, 296, 388

Coils 324

Cold Headed Parts 278, 384

Compressors 281-282

Connectors
Electrical 374
Hose 276, 292, 382-383
Tube 276, 292, 382-383

Contacts & Contact Materials..60-61, 253

Control Panels & Switchboards..263, 354

Controls
Electrical 34B-34C, 60-61 247-248, 260, 263, 309, 379
Electronic 247-248, 391
Hydraulic 103, 335, 342
Mechanical 368
Pneumatic 322, 335

Conveyor Belts 395

Copper & Copper Alloys 2, 43

Cords 277

Counters 17

Couplings (see Connectors, Electrical)

Couplings
Electrical 235
Hose 292
Hydraulic 324, 352
Mechanical 290, 350-351, 388, 398
Tube 292

Cylinders
Hydraulic 87, 121, 332
Pneumatic 87, 121, 332

D

Decalcomanias 360

Deep Drawing 110-111

Dials 354

Die Castings 265, 387

Dies 270

Differentials 396

Index of

PRODUCTS ADVERTISED

In This Issue

•

Drafting
Machines 128, 318-319
Supplies 35, 243, 318-319, 404

Drives
Adjustable Speed 106-107, 235
Timing 12
Variable Speed .....3rd Cover, 16, 310 353

Dynamometers 235

E

Electrical & Electronic Components, Custom Made (see also Production Services) 279, 336

Engine Indicators & Controls 124-125

Engineering Services (see also Production Services) 47, 222, 256 287, 321, 354

Engines 259, 268-269, 287, 305 361, 368

Extrusions
Metallic 2, 302, 355, 378, 393

F

Fabricated Plastics (See Plastics, Fabricated)

Fabricated Steel (see Plate, Fabricated, Sheet Fabricated, Structural Forms & Shapes, see Weldments)

Fastening Methods 37, 132, 255, 346 357, 384, 392

Felt 249, 327

Filters
Air 75, 331, 362
Hydraulic 331, 362

Finishing Equipment & Supplies 110-111

Fittings, Hose, Pipe & Tube..... 292 382-383

Fixture Clamps 264, 394

Flexible Couplings 344, 391

Flexible Shafts 334, 388

Forgings 56-57, 258, 271, 302 313, 347, 355

Furniture, Engineering Dept. ...35, 128 374

G

Gages, Pressure or Vacuum..... 286

Gaskets 122-123, 254

Gear Motors (see also Motor Reducers) .....3rd Cover, 96, 114, 310 377

Gears 6, 11, 246, 266, 339

Continued on p. 406

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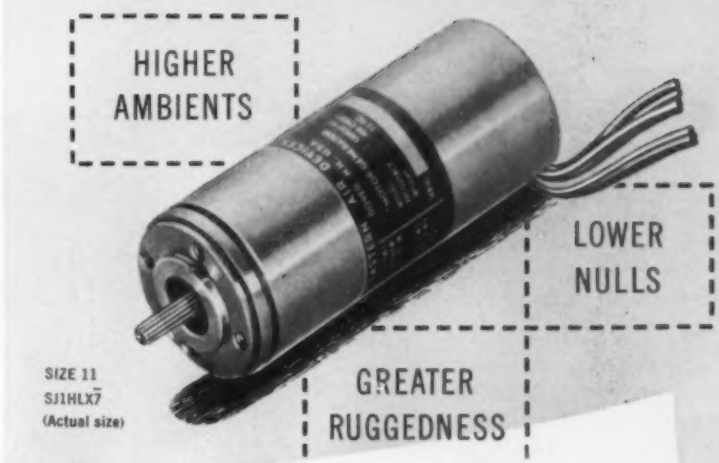

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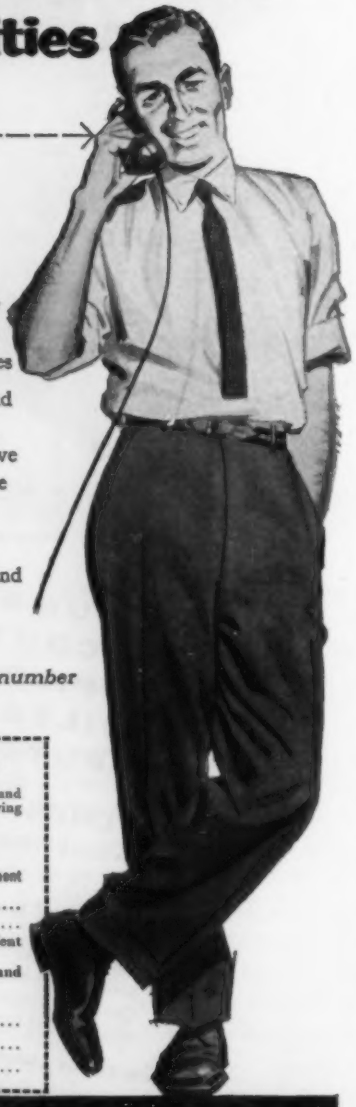

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Index of PRODUCTS ADVERTISED

In This Issue

Continued from p. 405

Generators
A-C 271, 405
D-C 106-107, 271, 405

Graphic Charts 388

Graphite 88-89

H

Heat Exchangers 93

Heating Units 90, 344

High Temperature Alloys 38, 389

Hose & Tubing 276, 292, 382-383

I

Instruments
Mechanical 360

J

Jewels 385, 392

L

Laminated Plastics (see Plastics, Laminated)

Latches 390

Leather .....2nd Cover, 241

Locks 346

Lubricants 250, 283, 374

Lubricating Equipment 267

M

Magnesium Alloys 378

Magnets 376

Manganese Alloys 97

Metal Bonded to Plastic 36

Moldings
Glass (see Glass Parts)
Plastics (see Plastic Parts)
Powdered Metal (see Powdered Metal Parts)
Rubber (see Rubber Parts)

Motor Reducers (see also Gear Motors) 45, 130, 310, 377

Motors, A-C
Fractional 26-27, 95, 117, 130 284, 307, 316, 359
Integral 26-27, 117, 359
Sub-Fractional 26-27, 130, 380

Index of

PRODUCTS ADVERTISED

In This Issue

•

Motors, D-C
Fractional 26-27, 95, 101A-101B 107, 117, 130, 284, 307, 359
Integral 26-27, 101A-101B 107, 117, 359
Sub-Fractional 26-27, 130, 380
Motors, Hydraulic 317, 329, 335, 345

N

Name Plates 354, 360
Nickel Alloys 38, 94
Nuts 14, 28-29, 37, 49, 66, 132 346, 403

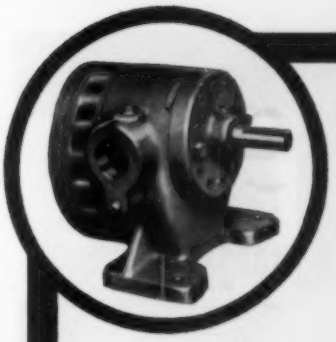
P

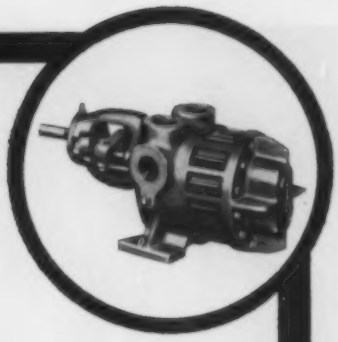
Packings 122-123, 241, 254 285, 352, 358, 372
Paints 333
Paper 289
Perforated Metals 362, 375
Phosphor Bronze 397
Pillow Blocks 44, 343, 350-351
Pilot Lights 60-61
Pins 49, 63, 392
Pipe 82
Plastic Parts 261, 279, 356
Plastics ..18-19, 33-34, 126, 252, 320, 414
Plastics Fabricated 78, 298, 320
Plastics Laminated 78
Plates 4, 102
Plates, Clutch 378
Powdered Metal Parts...8, 50-51, 71, 77 306
Power Take-Offs 271
Pressure Switches 394
Production Machines & Processes.... 127 357
Production Services (see also Engineering Services)..47, 110-111, 321, 354
Protective Devices, Motor..... 30
Pulleys 350-351, 398
Pumps
Air 362
Liquid 103, 274, 314, 317, 329, 342 345, 362, 370, 392, 394, 407, 415
Vacuum 362

R

Radioactive Sources & Materials.... 354
Recorders 72, 99

Continued on p. 408





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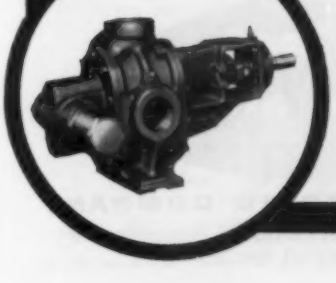

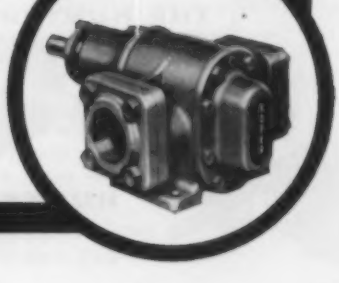

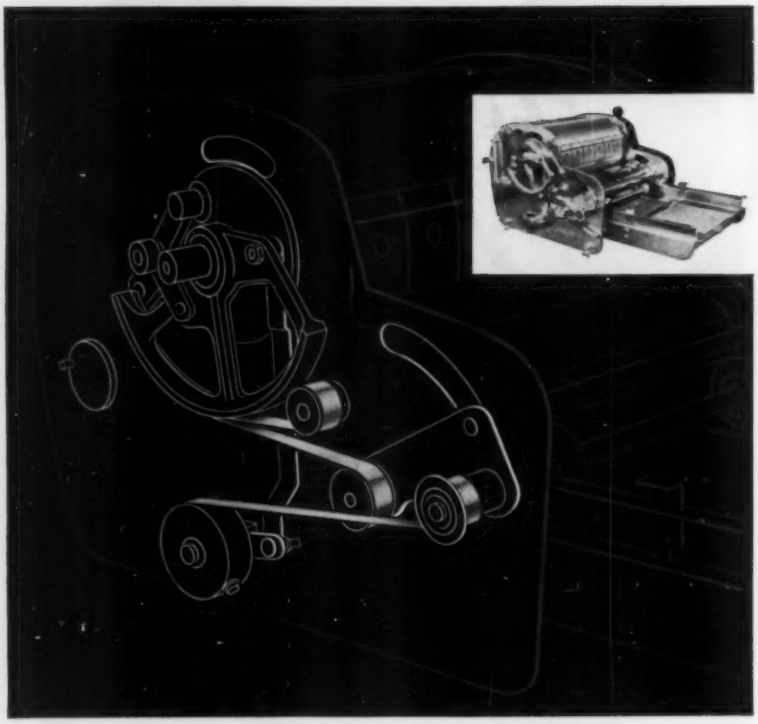

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Index of PRODUCTS ADVERTISED

In This Issue

•

Continued from p. 407

Regulators
Hydraulic 103
Pneumatic 75, 375

Relays 70, 106-107, 116, 218, 247-248 263, 275, 309, 314, 385, 412

Reproduction Supplies...243, 318-319, 404

Reproduction Equipment 318-319

Resins 40, 76, 126, 372

Retaining Rings 73, 337

Rings & Loops..... 239

Rivets 37, 92, 357, 384

Rod Ends 44

Rods
Metallic 43
Non-Metallic 298

Rubber 46, 81, 109, 231, 277, 369

Rubber Parts.....2nd Cover, 46, 91, 261 294

Rust Proofing 250

S

Screws 14, 32, 84-85, 118, 278, 384

Sealants 256

Seals ..2nd Cover, 91, 101, 122-123, 241 267, 285, 352, 358, 367, 378

Seating Work Equipment..... 386

Shapes, Rolled Formed..110-111, 341, 366

Sheaves 350-351, 398

Sheets
Metal 4, 315, 355, 411
Plastic 78, 298

Silicone Rubber 294

Silicones 34E-34F

Slides 326

Solenoids 220, 324, 356

Specialty Fasteners (Pipe Hangers, Special Cold Headed Parts, etc.)... 37 92, 108, 132, 278, 371, 390, 403

Speed Reducers 16, 42, 310, 339, 377

Splines 39

Springs 356, 398, 408

Sprockets 55, 297, 350-351, 398

Stampings 271, 279, 365, 398

Steel
Alloy 15, 20-21, 38, 58-59, 62, 97 233, 313
Carbon 233
Coated 233, 325
Stainless 4, 38, 58-59, 69, 97, 233 291, 299, 313, 315, 355
Tool 38

Strainers 362

Strip Metallic....4, 38, 233, 283, 315, 355 397, 411

Structural Forms & Shapes..... .366

Studs 278, 392

Switches ...52-53, 60-61, 74, 83, 244-245 247-248, 387, 410

Index of

PRODUCTS ADVERTISED

In This Issue

•

T

Tables, Dial-Feed 264
Testing Machines & Equipment..70, 242
Thermostats 48
Timers 72, 300, 349, 379, 385
Timing Motors 300, 303, 349
Titanium 34D
Torque Converters 271
Tracing Cloth 318-319
Tracing Paper 243, 293, 318-319
Transformers 324
Transmissions 271, 399
Traps (Steam) 304
Tubing
Flexible Metal 257, 382-383
Lock-Seam 341
Plastic 78, 252, 298
Seamless 15, 355, 416
Welded 38, 82, 355

U

Universal Joints 222, 253, 271

V

Valves
Air 1, 105, 113, 281-282, 322, 335 374
Control 1, 372, 374
Hydraulic ...41, 103, 105, 113, 329, 335 345, 368
Solenoid 1, 113, 263
Vibratory Equipment 242, 413

W

Washers 77, 255, 337, 346, 365
Washers (see Packings)
Welding
Equipment 86, 274
Nuts 409
Supplies 86
Weldments 239, 288
Wheels 280
Wire 4, 38, 67-68, 79, 279, 355
Wire & Cable.....67-68
Wire Cloth 112, 381, 395
Wire Forming 398
Wiring Devices 352

Z

Zinc Coated Sheets..... 325
Zinc Coated Strip..... 233

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If you're looking for a way to improve your product's performance *and* to lower your costs, more than likely this new Acro switch or one of Acro's many other designs is just what you need. We'll be glad to send descriptive literature—without obligation.

ACRO
MANUFACTURING COMPANY

SWITCH DIVISION
Columbus 16, Ohio
Plants at Columbus and Hillsboro
REPRESENTATIVES IN PRINCIPAL CITIES

INDEX TO ADVERTISERS

This index is published as a convenience to the readers. Every care is taken to make it accurate but PRODUCT ENGINEERING assumes no responsibility for errors or omissions.

A

Acme Chain Corp. 373
Acro Switch Div., Acro Mfg. Co..... 410
Acushnet Process Co..... 294
Allegheny Ludlum Steel Corp..... 355
Allen-Bradley Co. 247-248
Allen Mfg. Co..... 63
Allied Research Products, Inc..... 98
Allis Co., Louis..... 96
Alpha Molykote Corp..... 374
Aluminum Co. of America.....64-65
American Brass Co..... 43
American Chain & Cable Co., Inc... 286
American Cyanamid Co., Plastics & Resins Div..... 126
American Felt Co..... 327
American Hard Rubber Co..... 261
American Metal Hose Div., American Brass Co. 382-383
American Nickeloid Co..... 411
American Steel & Wire Div., U. S. Steel Corp.....69, 79
American Welding & Mfg. Co..... 239
Amforge Div., American Brake Shoe Co. 347
Arens Controls, Inc. 368
Armco Steel Corp. 4
Armstrong Products Co. 372
Atlas Chain & Mfg. Co..... 297
Automatic Electric Sales Corp..... 218
Automatic Switch Co..... 263
Automatic Temperature Control Co.. 379

B

Baldor Electric Co., Electric Motor Div. 359
Barksdale Valves 394
Beaver Precision Products, Inc..... 340
Bendix Aviation Corp., Eclipse Machine Div. 394
Bendix Aviation Corp., Pacific Div... 361
Bird Co., Inc., Richard H..... 385
Blood Brothers Machine Div., Rockwell Spring & Axle Co..... 222
Bodine Electric Co. 130
Browning Mfg. Co..... 398
Bruning Co., Inc., Charles....35, 318-319
Buffalo Bolt Co., Div., Buffalo-Eclipse Corp. 403
Bunting Brass & Bronze Co..... 306

C

Calidyne Co. 242
Cambridge Wire Cloth Co..... 395
Camloc Fastener Corp. 390
Cannon-Muskegon Corp. 389
Carpenter Steel Co. 38
Carpenter Steel Co., Alloy Tube Div. 82
Central Foundry Div., General Motors Corp. 20-21
Centralab Div., Globe-Union, Inc.... 336
Century Electric Co..... 117
Chace Co., W. M. 364
Chicago Rawhide Mfg. Co.....2nd Cover
Chrysler Corp., Industrial Engine Div. 259
Clare & Co., C. P. 275
Clark Controller Co. 309
Clearprint Paper Co. 293
Cleveland Cap Screw Co..... 278
Cleveland Worm & Gear Co..... 16
Cold Metal Products Co..... 233
Columbia-Geneva Steel Div., U. S. Steel Corp..... 69
Columbia Steel & Shafting Co., Summerill Tubing Co., Div..... 416
Conax Corp. 372
Cooper Alloy Corp. 291
Cramer Controls Corp. 72
Cramer Posture Chair Co., Inc..... 374
Crane Packing Co. 298
Crucible Steel Co. of America..... 299
Curtis Universal Joint Co., Inc..... 253

INDEX TO ADVERTISERS

D

Dana Corp. 271
DeLaval Steam Turbine Co..... 339
Denison Engineering Co., Subs., American Brake Shoe Co..... 342
Detroit Coil Co..... 220
Diamond Mfg. Co. 362
Dodge Mfg. Corp. 350-351
Dormeyer Industries 324
Dow Corning Corp. 34E-34F
Driv-Lok Pin Co. 392
Dudek & Bock Spring Mfg. Co..... 398
du Pont de Nemours & Co. (Inc.) E. I., Elastomers Div..... 231
du Pont de Nemours & Co. (Inc.) E. I., Polychemicals Dept.....33-34
Durakool, Inc. 387
Dynamatic Div., Eaton Mfg. Co..... 235

E

Eastern Air Devices, Inc..... 405
Eastern Industries, Inc..... 370
Eastman Mfg. Co. 292
Eastman Kodak Co., Graphic Reproduction Div. 243
Elastic Stop Nut Corp. of America... 49
Electric Auto-Lite Co., Wire & Cable Div. 67-68
Electric Wheel Co. 280
Electro Metallurgical Co., Div., Union Carbide & Carbon Corp.... 97
Electro Snap Switch & Mfg. Co..... 83
Elgin National Watch Co., Electronics Div. 314
Emmert Mfg. Co. 128
Enjay Co., Inc. 81

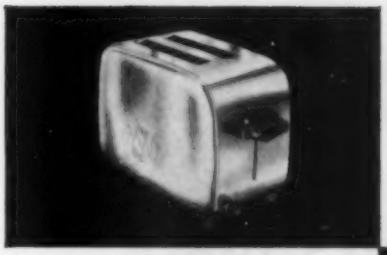
F

Fairfield Mfg. Co. 246
Fairbanks, Morse & Co., Magneto Div. 124-125
Fairchild Engine & Airplane Corp., Stratos Div. 375
Federal Mogul Div., Federal-Mogul-Bower Bearings, Inc..... 77
Federated Metals Div., American Smelting & Refining Co..... 380
Feltera Co. 249
Fenwal, Inc. 48
Firestone Plastics Co., Chemical Sales Div., Div. of Firestone Tire & Rubber Co. 40
Flexonics Corp. 276
Flour City Brush Co..... 398
Foote Bros. Gear & Machine Corp... 377
Ford Instrument Co., Div. of Sperry-Rand Corp. 396
Foster Mfg. Co., Inc..... 352
Frenchtown Porcelain Co..... 392

G

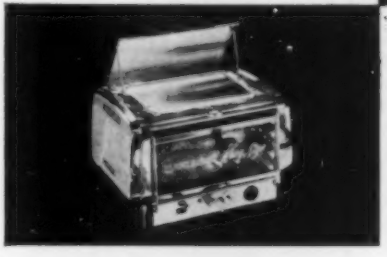
Garlock Packing Co.....122-123
Garrett Co., Inc., George K..... 365
Gates Rubber Co. 348
Gatti, Inc., Aurele M..... 392
Gear Specialties, Inc. 11
General Controls Corp..... 335
General Electric Co., Apparatus Dept. 70, 90, 101A-101B, 106-107
General Plate Div., Metals & Controls Corp. 31
Gibson Electric Co..... 253
Gits Bros. Mfg. Co..... 267
Gleason Works 6
Goodrich Co., B. F..... 37
Grant Pulley & Hardware Corp..... 326
Graphic Systems 388
Greene, Tweed & Co..... 352
Gries Reproducer Corp..... 387
Guardian Products Corp. 391

(Continued on Pg. 412)



Capitol Products Co., Winsted, Conn. — Triple plated (copper-nickel-chrome) steel toaster shell eliminates costly and dangerous hand buffing. Result: increased production, fewer rejects.

Century Enterprises, Inc., New York City — Fryer wrap-around of copper steel reduces scrap factor, eliminates post-plating. Result: increased production, lower cost, fewer rejects.



Marlun Manufacturing Co., Woodside, Long Island — Chrome steel rotisserie shell eliminates post-plating operation — saves 20% in production costs.

HOW MANY REJECTS CAN YOU AFFORD?

If you're plagued by a high scrap factor due to post-plating, buffing and excessive handling of plated metal components, check the advantages of pre-plated Nickeloid Metals. These modern *finished* raw materials have brought new methods of production to the appliance industry in a wide range of cost-saving applications: toaster shells, rotisserie bodies, fryer wrap-arounds, hot plates, heating element covers and decorative trim.

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NM

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Where the temperature hits 200°C. or the dry circuit is downright arid, your best bet for reliability is a "Diamond H" Series R miniature, hermetically sealed, aircraft type relay. Their shock and vibration resistance you may take for granted.

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Vibration Resistance:	10-55 cycles at 1/16" double amplitude 55-500 cycles at 15 "G" 55-1,000 cycles at 15 "G" 55-2,000 cycles at 20 "G"
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Coils:	Resistances—1 ohm to 50,000 ohms Arrangements—single coil; two independent coils, either or both of which will operate unit
Insulation Resistance:	1,000 megohms at room temperature 100 megohms at 200°C.
Dielectric Strength:	450 to 1,000 V., RMS
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Bulletin R-250 gives more complete data. Send for a copy.

THE HART MANUFACTURING COMPANY

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INDEX TO ADVERTISERS

(Continued from Pg. 411)

H

Hagen Mfg. Co., Subs. of Eagle Signal Corp. 303
Hanna Engineering Works 105
Hansen Mfg. Co., Inc. 300
Harrington & King Perforating Co. 375
Harrison Radiator Div., General Motors Corp. 93
Hart Mfg. Co. 412
Hartford Steel Ball Co. 360
Hassall, Inc., John 384
Haydon Co., A. W. 385
Haynes Stellite Co., Div. of Union Carbide & Carbon Corp. 80
Heim Co. 44
Heinze Electric Co. 380
Helicoid Gage Div., American Chain & Cable Co., Inc. 286
Hilliard Corp. 290
Hoffman Engrg. Corp. 352
Holo-Krome Screw Corp. 118
Hommel Co., O. 388
Houghton & Co., E. F. 285
Hunter Douglas Corp. 302
Hunter Spring Co. 408
Hyatt Bearings Div., General Motors Corp. 24-25

I

Industrial Metal Protectives, Inc. 296
Industrial Tectonics, Inc. 358
Ingersoll-Rand Co. 317
Inland Steel Co. 102
International Business Machines Corp. 330
International Harvester Co., Industrial Power Div. 305
International Nickel Co., Inc. 62, 94
International Packings Corp. 241

J

Jack & Heintz, Inc. 316
Jahn Mfg. Co., B. 270
Jeffrey Mfg. Co. 308
Johns-Manville Corp. 254
Johnson Machine Co., Carlyle 251

K

KSM Products, Inc. 274
Kaiser Aluminum & Chemical Corp. 22-23, 119-120
Kaydon Engineering Corp. 229
Keuffel & Esser Co. 404
Killan Mfg. Corp. 388
Kraissl Co., Inc. 362

L

Lamb Electric Co. 307
LaSalle Steel Co. 115
Lehigh Chemical Co. 283
Lermer Plastics, Inc. 356
Linde Air Products Co., Div. of Union Carbide & Carbon Corp. 86
Linear, Inc. 372
Link Belt Co. 55, 343
Little Giant Vaporizer Co., Inc., Little Giant Pump Div. 392

M

McGill Mfg. Co., Inc. 237
McGraw-Hill Book Co., Inc. 390
McLouth Steel Corp. 315
MB Mfg. Co., Inc. 413
Maas & Waldstein Co. 333
Madison-Kipp Corp. 265
Magnesium Co. of America 378

INDEX TO ADVERTISERS

Mahon Co., R. C. 288
Mallory & Co., P. R. 8, 74
Marbon Chemical Div., Borg-Warner Corp. 76
Marlin-Rockwell Corp. 312
Marsh Instrument Co. 360
Master Electric Co. ..... 3rd Cover
Mead Specialties Co. 264
Merkle-Korff Gear Co. 114
Metals & Controls Corp., General Plate Div. 31
Metals & Controls Corp., Spencer Thermostat Div. 30
Meyercord Co., Name Plate Div. 360
Micro Switch, a Div. of Minneapolis-Honeywell Regulator Co. 52-53
Midland Steel Products Co. 409
Milford Rivet & Machine Co., The 357
Miller Co. 397
Miller Fluid Power Div., Flick-Reedy Corp. 87
Milsco Mfg. Co. 386
Minneapolis-Honeywell Regulator Co., Industrial Div. 260
Minnesota Mining & Mfg. Co. 54
Minnesota Rubber & Gasket Co. 91
Monsanto Chemical Co. 18-19
Moraine Products Div., General Motors Corp. 71
Mosinee Paper Mills Co. 289
Mueller Brass Co. 56-57

N

National Acme Co. 244-245
National Cash Register Co. 323
National Lock Washer Co. 337
National Seal Div., Federal-Mogul-Bower Bearings, Inc. 32
National Tube Div., U. S. Steel Corp. 69
Newark Wire Cloth Co. 381
New Departure Div., General Motors Corp. 134
New York Belting & Packing Co., Gilmer Timing Belt Div. 12
Nicholson & Co., W. H. 304
Norgren Co., C. A. 75
Northern Ordnance Co., Inc. 274
Northern Pump Co. Subs. of Northern Ordnance, Inc. 274
Northrop Aircraft, Inc. 396

O

Onan & Sons, Inc., D. W. 361
Orange Roller Bearing Co., Inc. 262
Ortman-Miller Machine Co. 332

P

Packard Electric Div., General Motors Corp. 95
Palnut Co. 346
Parker Appliance Co. 101
Parker-Hartford Corp. 328
Parker-Kalon Div., General American Transportation Corp. 14
Parker Rust Proof Co. 250
Penn Metal Co., Inc. 112
Penn Precision Products, Inc. 283
Pennsylvania Flexible Metallic Tubing Co. 257
Perkins (Canada) Ltd., F. 287
Philadelphia Gear Works, Inc. 42
Potter-Brumfield Div., American Machine & Foundry Co. 116
Pratt & Whitney Aircraft 406
Precision Extrusions, Inc. 393
Precision Rubber Products Corp. 367
Presstite-Keystone Engineering Products Co., Div., American-Marietta Co. 256
Prestole Corp. 371
Protective Closures Co., Inc. 301
Purolator Products, Inc. 331

(Continued on Pg. 414)

FIGHT VIBRATION WITH VIBRATION

Shaker system for complex motion tests

NEWEST TECHNIQUE in environmental testing is complex motion testing. It comes closest to reproducing actual vibrational environments encountered in operation of missiles, aircraft, vehicles.

An MB Vibration Exciter System designed for such service is one of optimum versatility. It fulfills not only the special needs of *random motion testing*, but virtually any other test specification as well . . . such as sinusoidal motion testing, fatigue testing, automatic cycling, and provisions of MIL-E-5272A.

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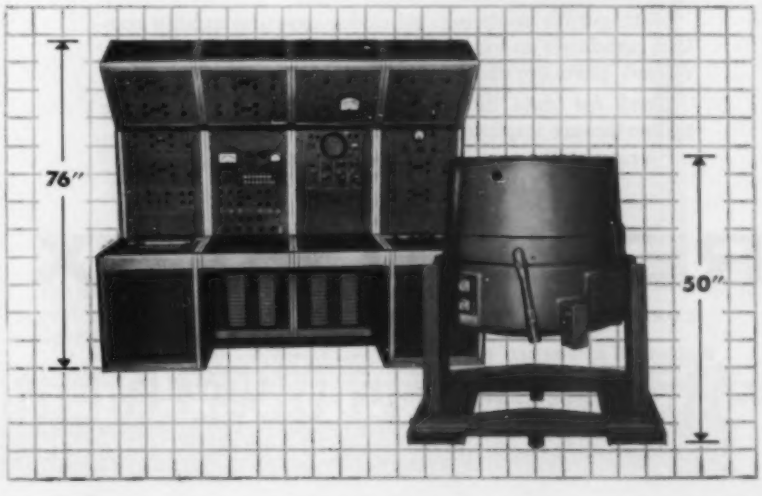

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INDEX TO ADVERTISERS

(Continued from Pg. 413)

R

Racine Hydraulics & Machinery, Inc. 345
Raybestos-Manhattan, Inc., Plastic Products Div. 252
Reeves Div., Reliance Electric & Engrg. Co. 353
Reliance Electric & Engrg. Co. 45
Rem-Cru Titanium, Inc. 34D
Republic Mfg. Co. 368
Republic Steel Corp. 28-29
Resistoflex Corp. 414
Revere Copper & Brass, Inc. 2
Reynolds Metals Co. 110-111
Ripley Co., Inc. 386
Robbins & Myers, Inc. 26-27
Rockford Clutch Div., Borg-Warner Corp. 378
Rockwood Sprinkler Co., Ball Valve Div. 41
Roll Formed Products Co. 341
Roper Corp., Geo. D. 407
Ross Operating Valve Co. 1
Rubatex Div., Great American Industries, Inc. 277
Russell, Burdsall & Ward Bolt & Nut Co. 108

S

SKF Industries, Inc. 363
Saginaw Steering Gear Div., General Motors Corp. 39
Sanborn Co. 99
Sandsteel Spring Div., Sandvik Steel, Inc. 356
Schrader's Son A., Div., Scovill Mfg. Co. 322
Scintilla Electrical Conn. Div., Bendix Aviation Corp. 374
Servo-Speed Div., Electro Devices, Inc. 391
Shakeproof Div. of Illinois Tool Works 255
Sharon Steel Corp. 313
Sier-Bath Gear & Pump Co., Inc., Gear Div. 266
Skinner Electric Valve Div., Skinner Chuck Co. 113
Smith Corp., A. O., International Div. 321
South Chester Corp., Southco Div. 92
Spencer Thermostat Div., Metals & Controls Corp. 30
Square D Co. 60-61
Stackpole Carbon Co. 376
Standard Pressed Steel Co. 66, 84-85
Sterling Electric Motors, Inc. 310
Stewart Corp., F. W. 388
Summerill Tubing Co., Div., Columbia Steel & Shafting Co. 416
Sylvania Electric Products, Inc. Parts Div. 279

T

Taylor Fibre Co. 78
Tennessee Coal & Iron Div., U. S. Steel Corp. 69
Thiokol Chemical Corp. 369
Thomas Flexible Coupling Co. 344
Timken-Detroit Brake Co., Rockwell Spring & Axle Co. 272-273, 295
Timken Roller Bearing Co. 4th Cover
Timken Roller Bearing Co., Steel & Tube Div. 15
Tinnerman Products, Inc. 132
Tomkins-Johnson Co. 121
Torrington Co. (Needle Bearing) 104
Torrington Co., Specialties Div. 47

INDEX TO ADVERTISERS

Tourek Mfg. Co., J. J. 34A
Trombetta Solenoids Corp. 356
Tru-Seal Div., Flick-Reedy Corp.... 378
Turco Products, Inc. 227

U

Union Carbide & Carbon Corp.
Electro Metallurgical Co. 97
Haynes Stellite Co. 80
Linde Air Products Co. 86
U. S. Axle Co., Inc. 338
U. S. Gasket Co. 320
U. S. Graphite Co., Div. of the Wickes Corp. 50-51, 88-89
U. S. Radium Corp. 354
U. S. Rubber Co., Mechanical Goods Div. 46, 100
U. S. Rubber Co., Naugatuck Chemicals Div. 109
U. S. Steel Corp.....58-59, 69
U. S. Steel Export Co. 69
U. S. Steel Supply Div., U. S. Steel Corp. 69
Universal Oil Seal Co. 358
University of California, Radiation Laboratories 311

V

Veeder-Root, Inc. 17
Vickers, Inc., Div. of Sperry-Rand Corp. 103
Viking Pump Co. 314
Virginia Gear & Machine Corp. 42
Vocaline Co. of America, Inc., Bristol Motor Div. 349

W

Wagner Electric Corp. 284
Waldes-Kohinoor, Inc. 73
Wales-Strippit Corp. 127
Webster Electric Co., Oil Hydraulics Div. 329
Weirton Steel Co. Div., National Steel Corp. 325
Weldon Tool Co. 415
West Virginia Works, Connors Steel Div., H. K. Porter, Inc. 366
Western Mfg. Co. 399
Westinghouse Electric Corp..34B-34C, 36
West Point Mfg. Co. 394
White Mfg. Co., S. S. 334
Wiegand Co., Edwin L. 344
Wiggins Oil Tool Co., E. B..... 324
Willys Motors, Inc., Industrial Engine Sales Dept. 268-269
Wisconsin Motor Corp. 368
Worthington Corp., Pump & Compressors Div. 281-282
Wyman-Gordon Co. 258

Z

Zenith Carburetor Div., Bendix Aviation Corp. 386

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EMPLOYMENT OPPORTUNITIES ...400-402

Index to Advertisers begins on P 410
Products Index begins on P 403

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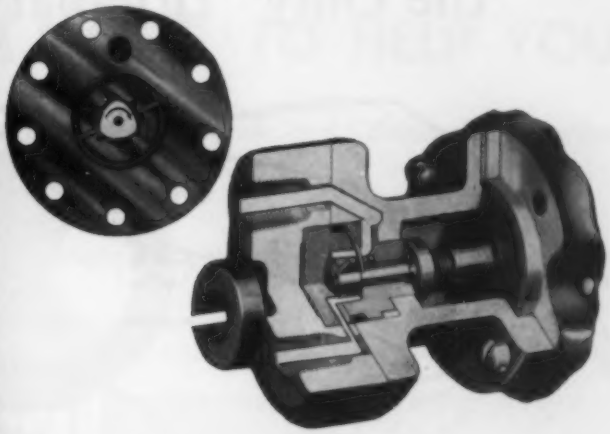

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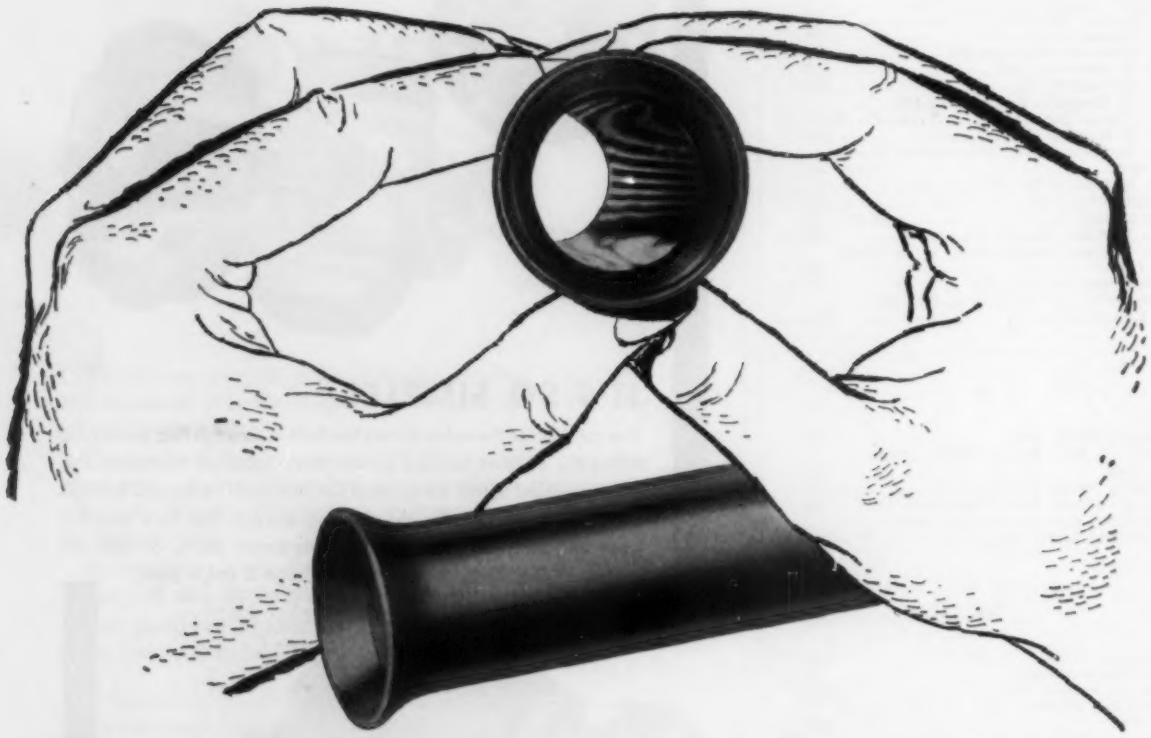

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To get more information about advertised products, circle the page number of the advertisement in which you are interested. If more than one advertisement is located on a single page, letters preceding number identify each advertisement. Key: T–Top; B–Bottom; R–Right; L–Left; TL–Top left; BL–Bottom left; TR–Top right; BR–Bottom right.

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5—Self-Wedging Nut
6—Mounting for Glass Panel
7—Solenoid-Operated Rotary Switches
8—Cam-Actuated Snap Switch
9—Valve Protector for Hydraulics
10—Compass and Ellipsograph
11—Gear Reduction Pulley
12—Thermostat for Up to 700 F
13—Subminiature Snap-Action Switch
14—Rotary Joint
15—Expansion Joints
16—Cam Limit Switch
17—D-c Power Rectifier
18—Single Turn Potentiometer
19—Self-Locking Nylon Nut
20—Two-Element Oil Pump
21—Vinyl-Coated Steel and Aluminum
22—Time Interval Meter
23—Subminiature Relays
24—Rigid PVC Pipe
25—Electronic Speed Control
26—Coincidence Thyratron
27—Panel Meter
28—Synchronous Clock Movement
29—T-Slot Bolts
30—Computing Relay
31—Miniature D-c Motors, Generators
32—Fuseholder and Fuse
33—Adhesive Aluminum Nameplates
34—Modeling Plastic Compound
35—Regulated D-C Power Supply
36—Self-Sealing Bolts
37—Metal Cabinets
38—Plug-in Totalizer
39—Transistorized Digital Counter
40—Molybdenum Disulfide
41—Transparent Labels
42—Brakemotors with Wide Torque Range
43—Switch for Two or More Circuits
44—Pressure Transducer
45—Synchronous Gear Motor
46—Preset Counter
47—Dual Relief Valves
48—Calibrated Expansion Valve
49—Motor-Gear Train
50—Fhp Motors in 48 Frames
51—Heavy Duty Step Switch
52—Multi-Contact Relay
53—Brass Solenoid Valve
54—Flange Union For High Pressures
55—Servo Actuator
56—Motor for Timing Units
57—Steam Trap
58—Snap-Acting Thermostat
59—Linear Scale Ammeters
60—Subminiature Potentiometers
61—High Deflection Hangers
62—Gear Pump for Up to 200 Psi
63—Color-Coded Gasket Stock
64—Subminiature Three-Pole Relay
65—Circuit Breaker
66—A-c Solenoid Has Solid Plunger
67—Quick-Connect Coupling
68—Operations Control
69—Control Circuit for Meter-Relays

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C2	1	2	4	6	8	11	12	14	15	16	17	18-9	20-1
22-3	24-5	26-7	28-9	30	31	32	33-4	34a	34b-c	34d	34e-f	35	36
37	38	39	40	41	42	43	44	45	46	47	48	49	50-1
52-3	54	55	56-7	58-9	60-1	62	63	64-5	66	67-8	69	70	71
72	73	74	75	76	77	78	79	80	81	82	83	84-5	86
87	88-9	90	91	92	93	94	95	96	97	98	99	100	101
101a-b	102	103	104	105	106-7	108	109	110-11	112	113	114	115	116
117	118	119-20	121	122-3	124-5	126	127	128	130	132	134	218	220
222	227	229	231	233	235	237	239	241	242	243	244-5	246	247-8
249	250	251	252	L253	R253	254	255	256	257	258	259	261	262
263	264	265	266	267	268-9	270	271	272-3	T274	B274	275	276	277
278	279	280	281-2	L283	R283	284	285	286	287	288	289	290	291
292	293	294	295	296	297	298	299	300	301	302	303	304	305
306	307	308	309	310	312	313	L314	R314	315	316	317	318-9	320
321	322	L324	R324	325	326	327	328	329	331	332	333	334	335
336	337	338	339	L340	R340	341	342	343	L344	R344	345	346	347
348	349	350	351	L352	TR352	BR352	353	354	355	L356	TR356	BR356	357
L358	R358	359	L360	TR360	BR360	L361	L362	R362	363	364	365	366	367
L368	TR368	BR368	369	370	371	L372	TR372	BR372	373	T374	BL374	BR374	L375
R375	376	377	L378	TR378	BR378	379	L380	R380	381	382-3	384	T385	B385
L386	TR386	BR386	TR387	BR387	T388	BL388	BC388	BR388	389	L390	R390	L391	R391
TL392	BL392	TR392	BR392	393	L394	TR394	BR394	395	L396	397	TL398	BL398	TR398
BR398	399	403	404	405	407	408	409	410	411	412	413	414	415
416	C3	C4											

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1	2	3	4	5	6	7	8	9	10	11	12	13	14
15	16	17	18	19	20	21	22	23	24	25	26	27	28
29	30	31	32	33	34	35	36	37	38	39	40	41	42
43	44	45	46	47	48	49	50	51	52	53	54	55	56
57	58	59	60	61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80	81	82	83	84
85	86	87	88	89	90	91	92	93	94	95	96	97	98
99	100	101	102	103	104								

CIRCLE THESE NUMBERS FOR COPIES OF NEW BULLETINS IN THIS ISSUE

106	106	107	108	109	110	111	112	113	114	115	116	117	118
119	120	121	122	123	124	125	126	127	128	129	130	131	132
133	134	135	136	137	138	139	140	141	142	143	144	145	146
147	148	149	150	151	152	153	154	155	156	157	158	159	160

Card expires March 1

CIRCLE THESE KEY NUMBERS..... FOR FURTHER DATA ON.....

CIRCLE THESE KEY NUMBERS..... FOR INFORMATION ABOUT.....

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USE THIS SPACE..... TO INDICATE REQUIRED.....

70—Hermetically Sealed Switch
71—Repeat Cycle Timer
72—Temperature Regulator
73—Miniature Magnetic Clutches
74—Flexible Duct
75—Variable Speed Transmissions
76—Solenoid Valve for 100 Psi
77—Miniature Slip Clutch
78—Mounting Clip for Small Parts
79—Step Valves
80—Electronic Proximity Control
81—Synchro Accurate to 3 Min
82—Re-rated Motors
83—Sector Potentiometer
84—Hydraulic and Pneumatic Cylinder
85—Pressure Switches
86—Single or Double-Wound Relays
87—Pillow Blocks
88—Terminal Blocks
89—Panel Raceways
90—Molded Variable Resistors
91—Relief and Back Pressure Valves
92—Cycle Timer
93—Stainless Steel Clamp
94—Vernier Potentiometer
95—Miniature Time Delay Relay
96—Potentiometer in Locking Bushing
97—Subminiature Terminal
98—Ultrasonic Soldering Iron
99—Circuit Continuity Tester
100—Dynamometer for Testing Servos
101—Digital Meter
102—Lettering Guide
103—Storage Oscilloscope
104—Circle Templates

NEW BULLETINS . . . listed below are described on pages 332-348. Circle key number for your copy.

105—Stamped Gears, 31 pp, Fastex
106—Fasteners, 23 pp, Fastex
107—Spring Design and Selection, 8 pp, Associated Springs Corp.
108—Variable Resistors and Switches, 30 pp, Stackpole Carbon Co.
109—Silicon Rectifiers, 11 pp, General Electric Co.
110—Standards for Stud Welding, 35 pp, K S M Products, Inc.
111—Synchros, 12 pp, Ford Instrument Co.
112—Fasteners, 12 pp, Shakeproof
113—Standards for Miniature Screw Threads, 17 pp, ASME
114—Lubrication Fittings, 8 pp, Universal Lubricating Systems, Inc.
115—Protective Coatings, 32 pp, Firestone Plastics Co.
116—Where Engineers Work in Industry, 11 pp, American Society of Tool Engineers
117—Metal Laminates, 8 pp, Bridgeport Brass Co.
118—Wire, Rod and Alloys, 28 pp, Techalloy Co., Inc.
119—High Pressure Gage Snubber, 2 pp, Chemiquip Co.
120—Phosphor-Bronze, 4 pp, American Silver Co.
121—Motor Operated Shut Off Valve, 2 pp, Hydromatics Inc.
122—Cluster Fittings, 44 pp, The Weatherhead Co.
123—Nuclear Reactors, 8 pp, Industrial Div., Minneapolis-Honeywell Regulator Co.
124—Casting Design as Influenced by Foundry Practice, 64 pp, Meehanite Metal Corp.
125—Swivel Joints, 12 pp, Barco Mfg. Co.
126—V-Belt Drives, 66 pp, Maurey Mfg. Corp.
127—Heat Exchangers, 12 pp, Young Radiator Co.

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PRODUCTS ADVERTISED

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348	349	350	351	L352	TR352	BR352	353	354	355	L356	TR356	BR356	357
L358	R358	359	L360	TR360	BR360	L361	L362	R362	363	364	365	366	367
L368	TR368	BR368	369	370	371	L372	TR372	BR372	373	T374	BL374	BR374	L375
R375	376	377	L378	TR378	BR378	379	L380	R380	381	382-3	384	T385	B385
L386	TR386	BR386	TR387	BR387	T388	BL388	BC388	BR388	389	L390	R390	L391	R391
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43	44	45	46	47	48	49	50	51	53	53	54	55	56
57	58	59	60	61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80	81	82	83	84
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133	134	135	136	137	138	139	140	141	142	143	144	145	146
147	148	149	150	151	152	153	154	155	156	157	158	159	160

SPECIFIC DATA . . .

Card expires March 1

128—**Fastenings, 64 pp, H. M. Harper Co.**

129—Push-Pull Remote Control, 4 pp, Controlex Corp. of America

130—Zinc Alloy Gears and Pinions, 1 pp, Gries Reproducer Corp.

131—Acrylic Rods, Tubes and Shapes, 4 pp, Ace Plastic Co.

132—Casting Alloys, Chart, Henning Bros. & Smith

133—Metal Powders, 6 pp, Metals Disintegrating Co., Inc.

134—1-5 hp Motors, 12 pp, General Electric Co.

135—Shaded-Pole Motors, 12 pp, General Electric Co.

136—Lubricated Plug Valves, 28 pp, Homestead Valve Mfg. Co.

137—Fastenings, 24 pp, H. M. Harper Co.

138—Push-Pull Controls, 30 pp, Arens Controls, Inc.

139—Relays and Switches, 10 pp, Jaidinger Mfg. Co., Inc.

140—Enclosed Switches, 24 pp, Micro Switch

141—Fluid System Specialties, 4 pp, Parker Appliance Co.

142—Aluminum, 16 pp, Joseph T. Ryerson & Son, Inc.

143—Sheaves, 16 pp, Fort Worth Steel & Machinery Co.

144—Flexible Couplings, 24 pp, Morse Chain Co.

145—Aluminum Mill Products, 24 pp, Kaiser Aluminum Inc.

146—Carbon-Graphite Material, 8 pp, United States Graphite Co.

147—Solderless Wiring Devices and Connectors, 8 pp, Electric Terminals Corp.

148—Sprockets, 19 pp, Cullman Wheel Co.

149—Electric Motors, 20 pp, Sterling Electric Motors, Inc.

150—Plastic Knobs, 15 pp, Kurz-Kasch Inc.

151—Flexible Metal Hose and Tubing, 64 pp, American Brass Co.

152—Glass Fibers, 6 pp, L.O.F. Glass Fibers Co.

153—Vulcanized Fibre and Laminated Plastics, Chart, National Vulcanized Fibre Co.

154—Plastic Pipe, 8 pp, American Hard Rubber Co.

155—Epoxy Resin Adhesives, 11 pp, Minnesota Mining and Mfg. Co.

156—Gyrol Fluid Drives, 8 pp, American Blower Corp.

157—Iron Powders, 14 pp, Republic Steel Corp.

158—Precision Instruments and Servo Parts, 128 pp, PIC Design Corp.

159—Screw Thread Inserts, 4 pp, Heli-Coil Corp.

160—Synchronous Induction Motor, 4 pp, Allis-Chalmers Mfg. Co.

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NEW YORK, N. Y.

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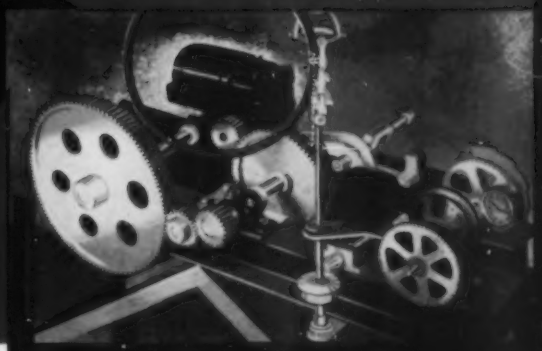
Requests for information made through *Product Engineering* Reader's Service will be forwarded to the manufacturer as quickly as we can process them. If you write directly to the manufacturer, please identify advertisement by issue and page number to facilitate reply.

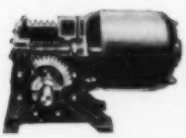
Nothing Cuckoo about this clock!



The "works" of a tower clock. 1/3 H.P., 115/230 volt, 60 cycle, 1 phase Master Right Angle Gearmotor supplies main drive with a synchronous output speed of 30 R.P.M.

You may not need clock drives, but time (production time) is a problem everywhere—and that calls for the most dependable, most efficient use of electric drives—like here! This clock, with 300 lbs. of hands and four 24-foot dials is powered by a Master Gearmotor driving a precision gear train. With that accurate Master drive, here's a one-jewel clock!

Are you sure you've got the right answer to your drive requirements? Master components can be integrated in any combination to give you the right horsepower, right shaft speed, right mounting features, in a single, efficient, compact unit. Now's the time to let us prove it.



MASTER ELECTRIC MOTORS

ANOTHER DRIVE REQUIREMENT MEETS ITS MASTER

Motor Ratings	1/8 to 400 H.P. All phases, voltages, frequencies.
Motor Types	Squirrel cage, slip ring, synchronous, repulsion-start induction, capacitor, direct current.
Construction	Open, enclosed, splash-proof, fan-cooled, explosion-proof, special purpose.
Speeds	Single-speed, multi-speed, and variable speed.
Installation	Horizontal and vertical, with or without flanges and other features.
Power Drive Features	Electric brakes (2 types)—5 types of gear reduction up to 432 to 1 ratio. Mechanical and electronic variable speed units—fluid drives—every type of mounting.

THE MASTER ELECTRIC COMPANY

Dayton 1, Ohio

New design cuts setup time— TIMKEN® bearings up precision

BECAUSE it has no cams to change, this Warner & Swasey 2AC Single Spindle Chucking Automatic sets up fast like a turret lathe, gives you automatic operation without the usual time-consuming setup procedures.

And among the many design features contributing to the lasting production accuracy of the 2AC is the mounting of the spindle on Timken® tapered roller bearings.

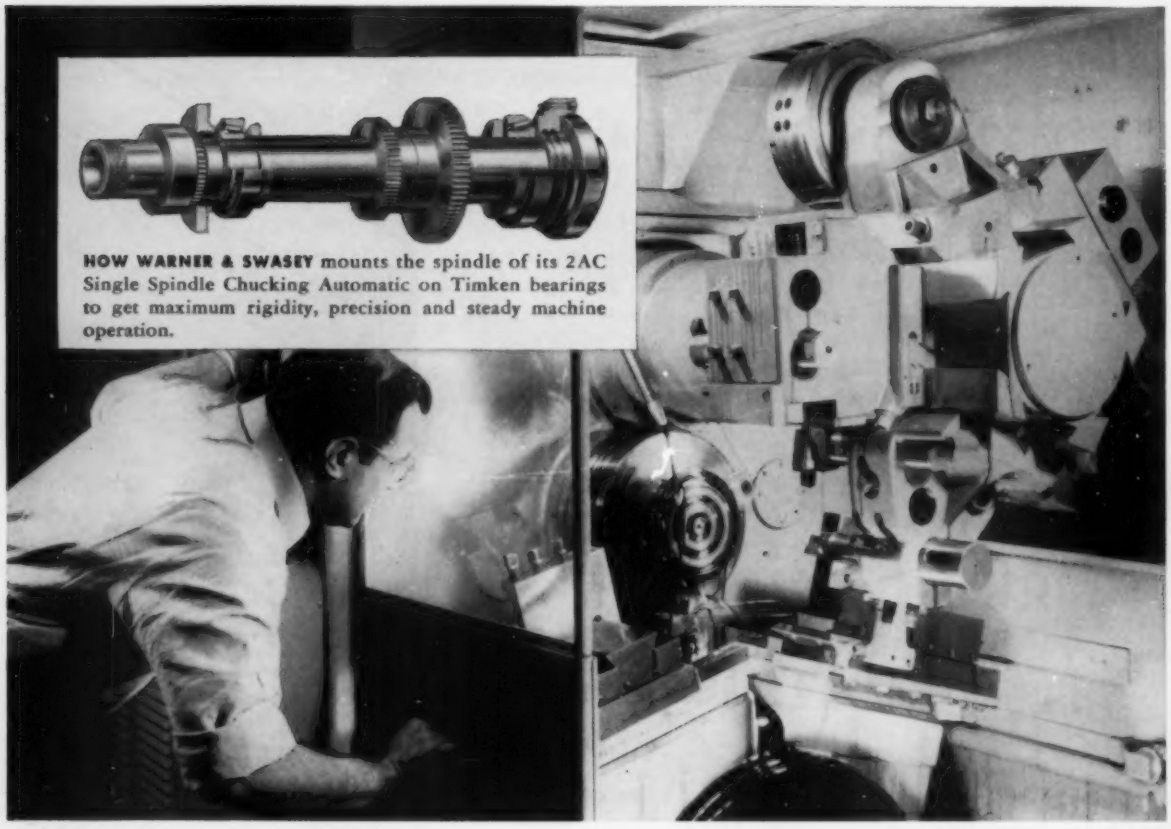
Because of their tapered design, Timken bearings take radial and thrust loads in any combination, hold the spindle in rigid alignment.

Full line contact between Timken bearing rollers and races provides maximum load-carrying capacity. And, because Timken bearings are built to last the life of the machine, maintenance costs go down.

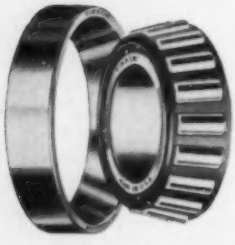
Timken bearings also save power because they practically eliminate friction. They are geometrically designed to give true rolling motion, precision manufactured to live up to their design. And to be sure we get steel good enough for Timken bearings, we make our *own* fine alloy steel. We're America's only bearing manufacturer that does.

No other bearings give you all the advantages that Timken bearings give you. That's why so many manufacturers of equipment that *must* have dependable bearing performance use them. Whether you buy or build machinery, be sure to specify Timken bearings. Look for the trade-mark "Timken" on every bearing. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ont. Cable: "TIMROSCO".

This symbol on a product means its bearings are the best.



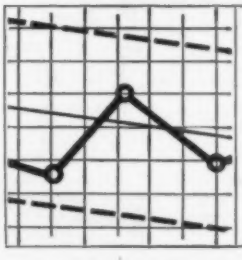
HOW WARNER & SWASEY mounts the spindle of its 2AC Single Spindle Chucking Automatic on Timken bearings to get maximum rigidity, precision and steady machine operation.



TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS



STATISTICAL QUALITY CONTROL

To insure uniform high quality and closer tolerances, the Timken Company uses statistical quality control. With it, tolerance deviations are plotted graphically. It's one of industry's newest, most scientific methods of improving product uniformity.

NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭ BEARING TAKES RADIAL ▯ AND THRUST ▯ LOADS OR ANY COMBINATION ▯